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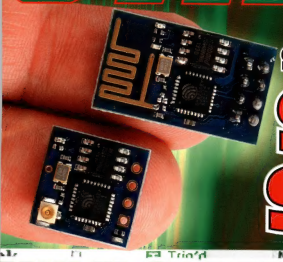

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POWER & MARINE KITS

Battery Saver Kit

Ref: Silicon Chip Magazine Sept 2013

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- PCB: 34 x 18.5mm

KC-5523

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Kit supplied with double sided, soldermasked and screen-printed PCB with SMDs pre-soldered, voltage setting diodes and resistors, and components.

Speed Control Kit for Induction Motors

Ref: Silicon Chip Magazine April/May 2012

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- Over-current, over-temperature, under-voltage, over-voltage and short-circuit protection
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- Up to 96% efficiency

*Does not work for motors with centrifugal switch

KC-5509

$249

Kit supplied with case, PCB, heatsink, cooling fan, hardware and electronics.

Ultrasonic Antifouling Kit

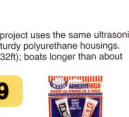
Ref: Silicon Chip Magazine Sept/Oct 2010

Marine growth electronic antifouling systems can cost thousands. This project uses the same ultrasonic waveforms and virtually identical ultrasonic transducers mounted in a sturdy polyurethane housings. The single transducer design of this kit is suitable for boats up to 10m (32ft); boats longer than about 14m will need two transducers and drivers.

- 12VDC
- Works with aluminium and fibreglass boats
- PCB: 104 x 78mm

KC-5498

$249



Pre-built antifouling systems also available:
Dual output, suitable for vessels up to 14m (45ft) YS-5600 $899
Quad output, suitable for vessels up to 20m (65ft) YS-5602 $1199

Kit supplied with control electronic kit and case, ultrasonic transducer, potting and gluing components, housings and wiring.

Jacob's Ladder Kit MKIII

Ref: Silicon Chip Magazine Feb 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects with even more zing and zap than its previous design from April 2007. Requires a VS Commodore 12V ignition coil (available separately from auto stores and parts recyclers).

- Powered from a 12V 7Ah SLA (SB-2486 $29.95) or 12V car battery (not included)

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AUDIO KITS

The "Super Ear"

Ref: Electronics Australia May 1998

This kit assists people who have difficulty in hearing high audio frequencies, or for those who want to hear more than their normal unaided ear. By amplifying these high audio frequencies, not only will conversations be made clearer, you will be able to hear noises not normally heard such as insects or a watch ticking.

- Headphones required
- PCB: 56 x 26mm

KA-1809

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Kit supplied with case, front label, PCB, 9V battery, and all electronic components.
Note: Not a replacement for a proper hearing aid.

Universal Stereo Pre-Amplifier

Ref: Silicon Chip Magazine April 1994

Designed for use with a magnetic cartridge, cassette deck or dynamic microphone. The performance of this design makes it a worthy replacement if your current pre-amp falls short of expectation.

- RIAA/IEC equalisation
- +/- 15VDC required
- PCB: 80 x 78 mm

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Kit supplied with all components to build either the phono, tape or microphone version.

Theremin Synthesiser Kit MKII

Ref: Silicon Chip Magazine March 2009

The ever-popular Theremin is better than ever. Create your own eerie science fiction sound effects by simply moving your hand near the antenna. Easy to set up and build.

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- PCB: 85 x 145mm

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"The Champion" Audio Amplifier Kit with Pre-Amplifier

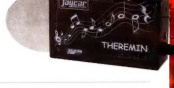
Ref: Silicon Chip Magazine Jan 2013

Suitable for general-purpose audio projects and supports microphone and electric guitar input. It uses the AN7511 audio IC to deliver 2W music power into 8 ohms from a 9 to 12V supply. Features low distortion, two inputs (mixed 1:1), mute and standby control.

- 4 - 13.5VDC required
- Output power: up to 4W
- PCB size: 101 x 41mm

KC-5519

$19.95



Kit supplied with silk-screened PCB, heatsink and PCB mount components.

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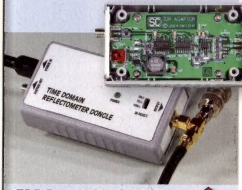

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Publisher's Letter

Argus could be a potent crime fighter

This month we have another story from Dr David Maddison, on the Argus-IS Wide Area Persistent Surveillance System. It is great story on the adaptation of consumer electronics, using hundreds of 5-megapixel camera sensors in a huge matrix which becomes a camera with a mind-boggling pixel count. But the picture resolution is only half the story because Argus can watch possibly hundreds of specific targets, looking for behaviour which is out of the ordinary. This generates stupendous amounts of data which can be analysed later to watch and trace specific events.

And while the article does not specifically state where the Argus system is being used, it has become apparent to me from recent news bulletins that it is almost certainly being used in the war-torn Middle-East, in finding specific targets.

That sort of application is no doubt what prompted its initial development but there is an even more intriguing side-story about its possible use in crime fighting. If you can imagine a group of these devices in drones way above a large city it would enable virtually any crime to be investigated after the event, whereby the perpetrators could be traced back to their initial departure point and also their subsequent escape route. Hence, investigators could tell the system to hone in on a bank robbery or a ram raid and trace the whole event.

Now while millions of CCTV cameras have been installed around the world and are regarded as useful in the fight against crime, they don't actually deter a lot of crime and they are sometimes not of much use in the subsequent investigation. And of course, criminals often do as much as they can to thwart any observation by CCTV cameras, from wearing masks to destroying the cameras. However, it is difficult to imagine how criminals could avoid observation by the all-seeing eyes in the sky! Maybe invisibility cloaks will become available!

But can you imagine the screams from the civil libertarians? They will ignore any possible benefit of the technology while shouting about the loss of "freedom". This seems to be symptomatic of our times – a new advance is announced and various interest groups then make a lot of noise about its possible drawbacks while ignoring the obvious benefits. Now while I would be the last person to regard all technological change as good, most of it is arguably, in fact, good.

As far as an eye in the sky is concerned, any potential loss of "freedom" seems to be the ability to commit a crime and go undetected. Alternatively, it might be the ability of people to do stuff they shouldn't be doing.

It reminds me of the case of a marina on Sydney's Pittwater which wanted to install a camera above the marina, so that clients could observe the weather conditions, much like many Sydney beaches have cameras to observe the surf. But no, some people were horrified at the possibility of being observed on their boat when supposedly the observers would otherwise think they were occupied elsewhere. With this possibility in mind, you can imagine any number of scenarios where people might be doing things during which they would wish to remain unobserved.

Never mind that such a weather camera could be of great utility to the majority of the marina clients. If you have a fly-bridge cruiser for example, wind can be a large factor in deciding whether you will go out for the day. A quick check of the camera and by looking at the flags, you would be able to judge wind speed and direction. If it's calm, out you go; if it's windy, perhaps not. And during a period of stormy weather, it would be good to be able to check how your boat is faring in the conditions. But for the moment, all that's on hold while the marina management tries to figure out an alternative approach. That's a pity.

Ultimately, the Argus-IS system is highly likely to be deployed over major cities. That could be a major benefit for most people. It would deter a lot of would-be criminals, thereby keeping those people out of jail, and there would be a lot less victims of crime. How can that be bad?

Leo Simpson

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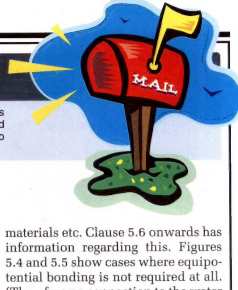

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Equipotential bonding in the MEN system

First and foremost, I must congratulate your team on producing such a fine magazine. I haven't missed an issue since mid-1992 and continue to construct many of your interesting projects. I am always amazed at how long you have maintained the excellent quality of the magazine.

I have been reading with interest the comments on the MEN earthing system and the possibility of water pipes causing electrocution etc. I have let the comments go but I am finally compelled to write. I have been an electrician for around 33 years now. My role for the last two and half years has been teaching electrical apprentices their trade training at TAFE.

There are two incorrect statements in the original article. First, the article states that the Neutral is earthed along the distribution system and water piping to minimise losses in the system. The sole purpose of earthing the Neutral conductor at regular intervals along the distribution system and at every installation via its MEN link is to keep the Neutral conductor close to zero volts with respect to the general mass of earth; nothing more, nothing less.

Currents do also return to Neutral via the ground and water pipes as a result of the parallel paths created by default but its purpose is not to reduce losses in the Neutral conductor.

Second, the article also implies that your water pipe is used as the main earth electrode and that you should install an earth spike if your water pipe does not make intimate contact with the ground. Using the water piping as an earth electrode was discontinued in the mid 1970s. The subsequent editions of the Australian Standards AS/NZS3000 require a dedicated earth electrode using table 5.2 in the current edition to select an acceptable material. The depths are given in the clauses just after that table.

The only time an earthing conductor is connected to water piping (apart from the older installations) is when equipotential bonding is required. The purpose is to reduce voltage differences between the earthing system and any conductive piping in contact with the ground by bonding them together.

It is required on metal parts of swimming pools, conductive building materials etc. Clause 5.6 onwards has information regarding this. Figures 5.4 and 5.5 show cases where equipotential bonding is not required at all. (Therefore no connection to the water piping is made in these cases).

The comments that really worried me were in the letter from Tom Pawson. His comments indicate that he has a poor understanding of the MEN system, as do many electricians for that matter.

Let me explain. All of the circuit (protective earth) wires from power points, lights, stove, hot water system, air-conditioning etc are run back to the switchboard and are either all soldered together or connected to an Earth bar. This bar or soldered joint is connected to an earth stake via the main Earth conductor. Its purpose is again to keep the main Neutral conductor and the installation earths at Earth potential. It does this via the MEN link which is a bridging conductor between the Neutral bar and the Earth bar.

When an active conductor shorts to the frame of a stove for example, the

What's in the name Currawong?

There is apparently much controversy about valve amplifiers. Technically, there can be little comparison between a semiconductor based amplifier and a valve based one. A well-designed and constructed semiconductor amplifier will always outperform a valve one. My electronics career began in the 1960s with valves and has evolved through life to everything we use today. My home entertainment amplifier is a good Denon system and speakers to match. It produces excellent quality sound, although my ears may not be as good as the system.

However, from my perspective that is not the issue. I spent most of my working life overseas and when returning to Australia, I needed a bedside light. I remembered the nostalgic glow of valves and a small pilot light so I rebuilt a vintage valve AM radio on a new stainless steel chassis, complete with pilot light. It makes a good bedside light and the radio still works.

I have been thinking about building a valve amplifier, not because it has inferior specifications or a "valve" sound but because it glows in the dark and Black Sabbath would still sound great. It is akin to people restoring or building vintage cars. They will never outperform a modern car but there are still reasons to do it.

I am curious about the name for the amplifier: "Currawong". Are you implying it squawks like a bird? Since I live in far North Queensland, I hope that you could arrange with a company to produce a kit of parts for the amplifier so that I won't have to hunt and gather the components individually.

Nigel Quayle,
Cairns, Qld.

Comment: as indicated in this month's article on the Currawong, Altronics will have a kit available.

The Currawong bird is endemic to the entire east coast of Australia, from far North Queensland to southern Victoria. It has a very loud and melodious call, often presaging rain. So we are definitely not implying that the amplifier squawks.

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Mailbag: continued

fault current travels back via the circuit (protective earth) conductor to the Earth bar, then via the MEN link back to the Neutral conductor (Fig.B5 in Appendix B in AS/NSZ 3000 gives a diagram to explain). The Neutral conductor provides the low impedance path back to the distribution transformer Neutral. The magnitude of this current is sufficient to operate supply protection (trip circuit breakers/blow fuses within the customer's switchboard).

Some current does flow via the Earth electrode and water pipes but this is not the intention and definitely must not be relied on. If the MEN link is left out and the same scenario above occurs, and there are no parallel paths via metallic water pipes (common in rural areas where poly pipe is used extensively), the resistance of the soil from the earth electrode to the nearest earth electrode connected to neutral may well be over 200Ω. (Note that AS/NSZ does not specify a minimum value for the resistance between the electrode and the soil).

This means that all earthed exposed metal in the installation (water pipes, metal kitchen sinks, white goods, concrete swimming pool reinforcing) will be raised to near the full 230VAC potential, awaiting contact with a human being or livestock.

Even without a fault condition, the standing earth leakage via stove and hot water elements, dishwasher elements etc can raise the potential of the earthing system if the MEN link is removed. This standing leakage can be below the level to trip RCDs so don't rely on them to be foolproof.

In fact, if you sign off an electrical installation and omit to install the MEN link you will be slapped with a serious defect notice by the electricity distributor and have your electrical licence cancelled.

You did well to advise Tom not to tamper with the MEN link. I hope he is not thinking of trying his experiments on electrical installations. Yes, always contact the supply authority if you receive tingles from taps. In fact, it is mandatory to report any electric shock no matter how minor to your electricity distributor for investigation before an electrician can be involved.

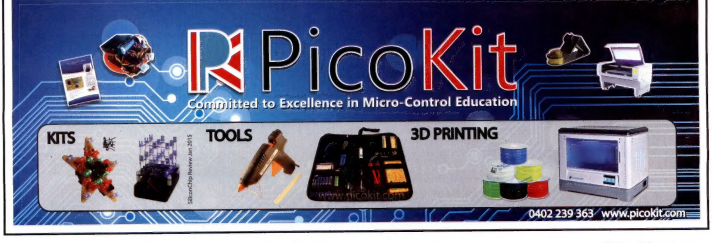
All of the hazards you have mentioned in the article are real and do exist. I hope this makes it all a little clearer for your readers and stops people who really don't understand what they are doing from fiddling with any electrical installation.

Once again thanks and keep the interesting articles and projects coming.

Geoff Coppa,
Emerald, Qld.

AM reception & interference from switchmode supplies

I must wholeheartedly agree with the points raised by your correspondent James Goding in the September



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Mailbag: continued

Cable PI tester gives MEN fault warning

The following information may be of interest to readers on the subject of broken Neutral conductors.

Several years ago Aurora Energy, the then electricity supply authority in Tasmania, supplied plug in units to detect a broken Neutral problem, to all residential and small business customers throughout the state. It is called "Cable PI" and details of its functions are explained on the website www.tasnetworks.com.au/safety/cablepi

The unit monitors the Active and Neutral of the supply so I assume that a differential reading is compared to a fixed voltage within the unit. My assumption is that in fault conditions, the increased Neutral to Earth voltage causes a lower differential reading and a point is set to trigger a LED (orange) to indicate a problem

and to contact TasNetworks. If the differential lowers further so that a dangerous voltage trigger point is reached, a red LED and audible signal indicate an emergency situation.

John Cairns,
Port Sorell, Tas.

issue, especially with regard to the deleterious impact LED lighting can have on AM radio reception. Living approximately 80km from our nearest AM transmitters in Melbourne, we are definitely "on the fringe" for MW radio reception.

But it's not just LED lighting that's causing medium-wave interference. Over the last five years, I have spent a lot of time (and money) in an attempt to locate and minimise multiple sources of interference which, at that time, made the entire AM band unlistenable. In the cases listed below, all the offending devices used switchmode power supplies with microprocessor control circuitry.

Amazingly, all the equipment was stamped as being EMC-compliant to the relevant Australian Standards and one manufacturer even faxed me a copy of their Certificate of Conformity. In order of severity, the following devices affected our AM reception:

(a) an Australian-made multi-zone air-conditioning unit (doesn't matter if the unit is off);
(b) an external water pump adjacent to our kitchen;
(c) our ADSL 2+ connection;
(d) various plugpacks for phones, modems, etc;
(e) a 1.5kW sinewave UPS;
(f) the washing machine and fridge;
(g) PCs, printers, routers and modems.

Depending on the degree of shielding, the problem is that the interference is both directly radiated from the offending devices and is also induced into power cables and other connecting cables which then may also radiate. In each case, I approached the various manufacturers/distributors of the suspect devices and while some replaced the interfering hardware, most were unable to offer any practical assistance.

When a portable AM radio was placed near our meter box, the ensuing band-blanketing racket had to be heard to be believed, so I had a licensed electrician check the Earth/Neutral

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Mailbag: continued

SILICON CHIP readers are not climate change experts

On page 6 of the October 2014 issue I read (with some amusement) of "the global warming religion". Of course, climate science and the faction that believes in anthropogenic warming lack that most distinctive, possibly defining, feature of religion: dogmatic belief in supernatural agency.

The irony here is that research shows that scientists are less likely to profess any religious belief than the general public, while global warming deniers are more likely to profess some religious belief, and people who put trust in God ahead of trust in science are often inclined to reject evidence that does not comport with their preconceived ideas, rather than adjusting their ideas to fit established fact.

I must say though that I am staggered by the enormous expertise of SILICON CHIP readers in the field of climate science, expertise which obviously exceeds that of the United States Geological Survey (a government funded body that "provides the nation with reliable, impartial information to describe and understand the Earth") and the Intergovernmental Panel on Climate Change ("the leading international body for the assessment of climate change" . . . "established by the United Nations Environment Programme").

If the USA and the UN can't employ competent scientists they (those SILICON CHIP readers who are climate science experts) owe it to the world to offer their services to one or other of these august bodies, to save humanity from an awful lot of bother and wasted resources. Their talents are wasted just writing querulous letters to Australia's premier electronics magazine.

Phil Denniss,
Darlington, NSW.

Comment: it seems that quite a fair proportion of global warming believers also subscribe to the Gaia hypothesis or theory. Does that not fit the definition of a religion in being a supernatural agency?

Nor can the IPCC be regarded as an objective body representing the views of climate scientists, since so many prominent practitioners in the area are excluded from its reports. Finally, around the world, many national bodies which are charged with providing reliable and impartial information clearly have a particular bias.

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wiring of the mains. Then I attempted other solutions, such as placing metal shielding (where practicable) around offending devices, running shielded-twin pair for the ADSL line, mounting a coax-fed external AM loop, fitting ferrite toroids on power leads and employing various mains filters.

No one solution has proved to be the "magic bullet" but taken together, the above measures have enabled us to receive the ABC fairly well, with only a slight background "rhythmic burp" from the air-conditioner. Of the commercial stations, MyMP and Magic 1278 are now listenable though still with some background noise.

I should mention that an approach to the ACMA proved most enigmatic – they said that as I had identified the sources of the interference, I should contact the manufacturers, as they were unable to help. They did suggest digital radio but for our location this would require an outdoor antenna and frankly, I still think that AM radio – given a good broadband receiver fed with a strong signal in a noise-free environment – sounds superior to its digital equivalent. But of most concern is my impression that there is just no enforcement of the various EMC standards and consequently, AM radio's rural listeners are the first to suffer.

Perhaps this is a topic that SILICON CHIP could take up – a primer on EMC coupled with a summary on the best approaches to tackle AM radio interference.

Norman Hughes,
Flinders, Vic.

Comment: while suppression of AM interference from electrical appliances is most important for people who live in weak signal areas, a good complementary approach is to build a noise-cancelling loop antenna.

Readers can refer to four projects in SILICON CHIP for loop antennas and all are based on loops of multi-strand cable (eg, ribbon or Cat-5) with all stands linked to form a single loop. Just go to **www.siliconchip.com.au/project/loop+antenna**

The Currawong valve amplifier brings on nostalgia

Thank you for presenting the Currawong Stereo Valve Amplifier. It has prompted me to remember my long-distant past of building valve amplifiers in my teens. In those days, Oxford Street, Sydney was alive with three or four surplus stores which sold all sorts of "junk" which I used to lug home on the bus.

I remember purchasing a very heavy WW2 radar with 45 valves and a 3BP1 CRT from which a friend and I built a 3-inch CRO. We turned it on with two broom sticks tied together.

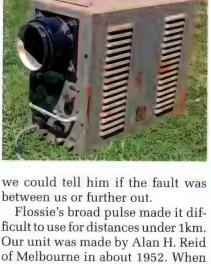
I took great joy in stripping these things and finding amazing quality

TDR article brings back memories

You article in the November SILICON CHIP regarding TDR has brought back many memories and a trip to the far corners of the shed. In the 1980s, I worked for the Hydro Electric Commission in Tasmania and a regular task was to locate faults on EHV transmission lines and (more often) in the physical phone lines that ran beside them.

The test equipment was a "Fault Locator On Screen", fondly known as Flossy. Weighing in at 24kg, it was a long haul into the switch-yard with Flossy and the associated equipment to connect her to the transmission line. Flossy put out a pulse of around 3MHz and could reliably locate faults within a few hundred metres on a 50km-long transmission line.

There were controls for "range" and "expand" as well as distance markers to make the locating relatively easy (after years of practice). If we needed to get closer, the linesman would put an earth on the line and



we could tell him if the fault was between us or further out.

Flossie's broad pulse made it difficult to use for distances under 1km. Our unit was made by Alan H. Reid of Melbourne in about 1952. When it was replaced by a new unit in the early 1990s I was able to rescue Flossy but the operating manual was lost.

The new replacement was easier to carry around but the LCD was not as easy to interpret as the old CRO.

Jim Hiley,
Stowpart, Tas.

ceramic valve sockets, potted transformers and other bits and pieces which were useful. I built a Mullard 5+5 from the then-popular *Mullard Audio Guide* and when that died I kept the A&R output transformer.

Later, I was given a beautiful Leak valve amplifier which I restored and basked in the glow of the 10 or 12 valves.

In my professional life, I started work in the days just before the IBM PC was released, doing taped handlayouts of PCBs right through to these days of using Altium. I have developed products using 6502 processors all the way through to the Intel 186 and Hitachi 16-bit processors in medical and commercial products, programmed them all and have used Labview now for many years.

I recently located an old long-lost de Forest triode and decided to make myself a small display for my lab. I added the first available commercial IC, the Fairchild FuL914 (a dual transistor) which I purchased in 1969 and used in a multivibrator. To that I added a 586 processor. So on the one block rests a single triode, a dual transistor IC and a 200,000 transistor IC. I used this to explain to my son recently about the operation of a modern day computer.

The most impressive item in your article however is the reverse use of the line output transformer, giving remarkable linearity from a no doubt fairly cheap transformer.

When I looked at the power supply, I thought of a single 5V4 (if I remember the number correctly!). Lastly I recall complaining to Neville Williams, in the days of *Electronics Australia*, a long time ago, about the lack of valve projects and recall a reply something along the lines that "technology moves on" and so it does. However, the glow of a valve or two is a very special effect and the sound is very satisfying.

Braham Bloom,
Five Dock, NSW.

Science is not sacrosanct

In the Mailbag pages of the November 2014, one of your readers claimed that science was being denied. I assume that he is referring to the criticism of global warming or climate change. Science is not sacrosanct. It is

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Mailbag: continued

Cars with keyless entry can trap children

I refer to the letter in your November 2014 issue on cars with keyless entry. Several anecdotal accounts I have seen or heard lately have raised other concerns. Some cars seem likely to have issues with two sets of keys in the car and my son's car has a potentially dangerous anti-theft feature – left shut and unlocked, after a few minutes, it locks itself, and cannot be unlocked from inside. The potential for trapping young children inside is obvious and in summer, dangerous.

But perhaps the worst I have heard of was a current model luxury car. This suffered a catastrophic total electrical failure resulting in a rapid drop of voltage (due to a short in the starter). This resulted in shutting down the engine and applying the electric parking brake. With fully electric door locks and windows and no internally operable mechanical locks, it left the occupants trapped in an unlighted vehicle, immobilised in the middle of the road.

I won't mention the brand of vehicle because I suspect that this could potentially happen with many modern vehicles with high anti-theft capability and my understanding is that this event is the subject of legal action.

John Denham,
Elong Elong, NSW.

a work in progress and needs correction when wrong. Our scientific database is far from complete and there is so much that the scientific community doesn't know. That is why research is conducted and sometimes with incorrect results.

There are many reasons why research may produce incorrect results and obviously it is not done on purpose, but one factor is that many scientists have is a narrow education. It is one of the things that I observed during my years working at a university. Outside of their chosen field, they have quite limited expertise and it is not by chance. They are so committed to their field of study that they neither have the time nor inclination to expand their knowledge into other fields. In doing so, they leave themselves open to errors. No field of science is independent from others and invariably bad hypotheses are made because unseen external factors were not taken into account.

A highly-specialised and narrow expertise is common and can be seen in the various titles of engineers and technicians, medical specialists, the trades etc. I certainly would not ask an economist for advice about designing a PCB and I'm certain an economist would not ask for advice from an engineer concerning economics. Even so, all the professions are subject to external factors which can result in them being subject to criticism. Why should the scientific community be exempt?

There is something else that concerns me and that is the future of hobby electronics. Where is it headed? A valve amplifier does worry me. Will the next project be a wide-band spark gap transmitter using modern components? Or, does SILICON CHIP go to the leading edge of the 21st century with projects that require large ball grid array chips etc with data sheets approaching a thousand pages?

I have noticed subscribers asking for both simple and complex projects and over the years there has been a good variety of projects and articles. Currently, SILICON CHIP is the last electronics magazine in Australia and one of a few in the world and I believe that survival has been due in part to the wide range of subjects that the magazine presents. If SILICON CHIP had been restricted to purely electronics, I believe reader numbers would have been quite small.

It is a pity that there has been almost nothing concerning my interests of

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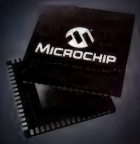

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Mailbag: continued

robots and artificial intelligence but I still look forward to receiving SILICON CHIP and I enjoy reading it.

George Ramsay,
Holland Park, Qld.

Comment: we have heard of people playing with old-time coherers using a modern electric welder as the spark gap transmitter.

Possible hazard with rust removal process

I found your October 2014 article on "How to Remove Rust by Electrolysis" very interesting. It brought back many memories of my apprenticeship in the aircraft industry. It also brought back memories of "hydrogen embrittlement" in metals and the dangers therein. In the aircraft industry, many base metals were electroplated with sacrificial metals to protect them from corrosion.

During the electroplating process, hydrogen atoms are released on the surface of the metal being plated. These atoms are mainly released into the electroplating solution, where they combine with other hydrogen atoms, and simply rise to the surface of the liquid as bubbles of molecular hydrogen. However some atoms can diffuse into the base metal being electroplated. They can "slip" between the base metal molecules, and then combine with another hydrogen atom, to form a hydrogen molecule. These molecules can then exert pressure inside the base metal which, if great enough, can cause it to crack open.

From memory, the metals we were most concerned about were steels with high tensile strength. These had to be heat-treated within 30 minutes of removal from the plating tank, in a fan-forced oven set at 120°C for a minimum of eight hours. Because these steel taper pins held the wings onto the aircraft, it was most important that the process was correctly followed!

I am sure that if the "How To Remove Rust By Electrolysis" process is used to remove the rust from say tent pegs, there will not be much danger from hydrogen embrittlement. However, if rust were to be removed from say a crankshaft, this would be of concern. We had several crankshafts fail after electroplating by cracking in half. This seemed to be from hydrogen embrittlement. The internet has much information on this subject.

Tony Farrell,
Kingscliff, NSW.

Wind power a hazard for coal-fired generators

Many continue to believe that intermittent renewables, such as grid-connected wind farms and solar PV arrays, can readily provide the means to reduce CO_2 emissions. A recent report on experience of the impact on the German electricity grid from the huge fleet of wind generation in that country casts considerable doubt on wind's usefulness and therefore its ability to reduce emissions.

It also demonstrates the many ways in which the heavily-subsidised large-scale installation of wind farm generation poses real dangers to continued grid operation, both by its impact on the economic viability of the still-required fossil-fuelled generation and its ability to cause actual

mechanical damage to those generators.

Wind energy, even when provided by wind farms scattered widely over the far-flung eastern Australian grid, remains stubbornly intermittent, as the studies of Miskelly & Quirk (2010) and Miskelly (2012) show. It is this inherent intermittency that makes wind generation incompatible with the operational requirements of both the grid demand profile and other generators.

As the more recent report illustrates, because wind energy is intermittent, all existing forms of generation on the grid must remain connected, if only to supply load requirements when wind fails; yet, perversely, wind generation affects the financial viability of this essential generation to such an extent that operators are closing down the very resources required to keep the grid operational.

Furthermore, because the grid must remain in balance instantaneously or face blackout, fossil-fuelled generation must be able to act instantaneously to compensate for wind's vagaries, placing huge transient mechanical loads on that generation as a result.

As the report's Appendix 1, a paper from Siemens, on the impacts of wind's intermittency on actual gas and coal-fired generators shows, real mechanical damage results, requiring more frequent maintenance and significantly shortening the operational lifetime of this plant. This description of the severe impacts on the operational lifetimes of both gas and coal-fired plant now having to be used in back-up mode for renewables is particularly revealing and to the engineer, is very scary stuff indeed.

This recent report: "Development And Integration of Renewable Energy: Lessons Learned From Germany", Finadvice, July 2014, is available at: http://www.finadvice.ch/files/germany_lessonslearned_final_071014.pdf

Paul Miskelly,
Mittagong, NSW.

References: Miskelly A & Quirk T, 2010, Wind Farming in South East Australia. Energy & Environment, Vol. 20, No. 8, 2009/Vol. 21, No. 1, 2010. Multi-Science Publishing: http://multi-science.metapress.com/content/j2l218v143733536/?=6a6a9906f9054f6d9fefb8df6ddfbb158&pi=2

Miskelly P, 2012, Wind Farms in Eastern Australia – Recent Lessons: http://multi-science.metapress.com/content/f1734hj8j458n4j7/?p=8b0b5726bef043719b0f2f78536679f4&pi=4

DC switching needs DC isolators

When I read the letter titled "Solar panels for hot water" on page 9 of the Mailbag section of the November 2014 issue, I was surprised that in the comment that followed, no reference was made to the error in using AC-rated switches and thermostats for DC applications. The reason that the thermostat would have melted would be because once the disconnect arc had been started it would have kept going in the plasma produced and as happened melted the contacts.

If the current was AC the change in current direction, hence drop in current to zero before increasing again, would have extinguished the arc. DC isolators have physically larger open contact distances and/or an insulating gate that closes between the contacts.

Tom George,
Ballarat North, Vic. SC

By Dr David Maddison

ARGUS-IS

Wide Area Persistent Surveillance System

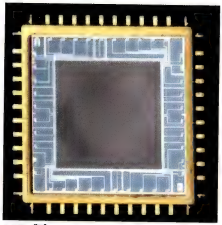
Developed by BAE Systems, ARGUS-IS combines a 1.8-gigapixel camera with advanced software, enabling it to find, monitor and track multiple targets over a wide geographic area. Here's a look at its capabilities.

ARGUS PANOPTES or Argos is the "all seeing" giant from Greek mythology, often described as having multiple or even one hundred eyes. The Ancient Greek epic poem *Aegimius* states, in fragment five: "And [Hera] set a watcher upon her [Io], great and strong Argos, who with four eyes looks every way. And the goddess stirred in him unwearying strength: sleep never fell upon his eyes; but he kept sure watch always".

It would be difficult to come up with a more fitting name for ARGUS-IS, BAE Systems' Autonomous Real-Time Ground Ubiquitous Surveillance Imaging System. This is a 1.8-gigapixel aerial surveillance system that offers an unprecedented ability to find, monitor and track multiple simultaneous targets of interest over a wide area in real time.

ARGUS-IS was developed as an airborne "Wide Area Persistent Surveillance System" and is designed to monitor areas of interest for many hours, days, months or even years. The system is intended for use in the battlefield and against locations such as cities and towns where insurgents (or others) might live and conduct terrorist activities. It "sees and records all". For example, if a terrorist or other enemy attack occurs and the enemy activity had not previously been detected, it is possible to review the recorded video data to see where the enemy came from and then take appropriate action against them at the originating location.

In operation, the system can resolve objects as small as 15cm from 5300 metres altitude (and possibly smaller objects with image processing). The project was funded by the USA's Defence Advanced Research Projects Agency (DARPA). This was initiated in 2007 with US$18.5 million from DARPA to BAE and the system was first flight tested in February 2010. Operational status with the US Air Force



368 of these 5-megapixel sensors are used in the ARGUS-IS system. Note the non-pixel elements and the package and interconnecting pins around the edge of this chip, explaining why ARGUS-IS requires a mosaic of four arrays to provide full sensor coverage.

This official US Air Force photograph, taken at Kandahar air field in Afghanistan on August 18th this year, shows a General Atomics MQ-9 Reaper with two sensor pods. One is labelled "EO" meaning electro-optical and the other is labelled "IR" meaning infrared. It is postulated that the EO pad contains an ARGUS-IS sensor. The other pod might contain the infrared version, designated ARGUS-IR.

was achieved on July 1st, 2014 when the ARGUS-IS sensor was incorporated in a "Gorgon Stare" pod aboard a General Atomics MQ-9 Reaper unmanned aerial vehicle (UAV).

Traditional surveillance platforms have a "drinking straw" view of what is beneath them and have to swivel and zoom to view targets of interest. In addition, multiple passes over a target of interest might be required to gather the required data. The wide-area context of any activity is often not seen because only a zoomed-in view is available. Most traditional platforms also acquire only limited amounts of data and are not designed for persistent surveillance or automated analysis of the recorded data.

By contrast, a Wide Area Persistent Surveillance System such as ARGUS-IS can monitor large areas and even an entire city of up to 100 square kilometres and "stare" at the scene. Because of its extremely high sensor resolution, it's unnecessary to physically zoom or swivel the image sensor. Instead, targets of interest can be seen by electronically zooming in on parts of the image. In addition, multiple targets can be seen and monitored simultaneously on the electronic image.

Airborne platforms for the imaging system can include a variety of conventional unmanned aerial vehicles (UAVs or "drones"), aerostats (balloons or powered airships) and conventional aircraft, although its primary mission role is long term surveillance. Thus, an aerial platform with a long "loiter time" capability is preferred. Solar-powered UAVs now in development could even provide continuous surveillance for years at a time.

The Boeing SolarEagle is a solar and hydrogen fuel-cell powered aircraft which is under development and is designed to stay airborne for indefinite periods. It might be considered to be an "atmospheric satellite". In the near future, a platform such as this could be used for ARGUS-IS persistent surveillance. Other aircraft such as airships are also under development for this purpose.

Making the sensor

Clearly, making an image sensor with 1.8-gigapixel resolution would be a difficult task with present technology. At the moment, the highest resolution image sensor available is the Gpixel GMAX3005. This is a monochrome sensor with 150 megapixels resolution and is capable of 10 frames per second in full frame mode.

So how was an image resolution, in colour, with more than 12 times the current highest-resolution monochrome chip achieved? The remarkable way that this was done goes back to the initial requirements for the system. It had to be done both quickly and relatively cheaply.

Necessity being the mother of invention, scientists and engineers decided that the best way to achieve this resolution was to use off-the-shelf civilian

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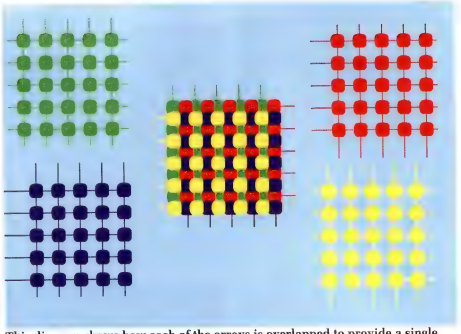
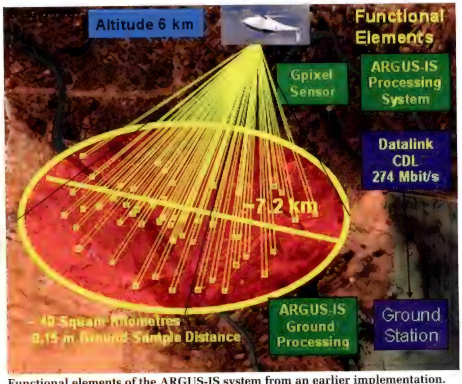


This diagram shows how each of the arrays is overlapped to provide a single, seamless mosaic image. Note that each array is offset by exactly the width of one sensor element in either the vertical or horizontal direction.



Functional elements of the ARGUS-IS system from an earlier implementation. Note that the area monitored is now around 100km², not 40km² as shown here, and the robotic helicopter platform has been discontinued. Each individual yellow square represents a surveillance target. There is both on-board and ground station data-processing.

technology of the type that almost everyone carries in their pocket – image sensors from mobile phones. Basically, 368 5-megapixel mobile phone sensors were used to make a composite focal plane array (CFPA) capable of imaging at up to 12 frames per second (although some literature says 10).

However, there is the obvious problem of what happens at the edges of these individual sensors where there are no imaging elements. If a single array was used, there would normally be vertical and horizontal blank lines

Believed to be a demonstration of the technology rather than the enactment of a real crime, this example from Dayton, Ohio shows how Wide Area Persistent Surveillance could be used to track a suspect vehicle. In this case, the observing vehicle was a manned aircraft and neither ARGUS-IS or Persistics were used. The company involved with this technology is Persistent Surveillance Systems.

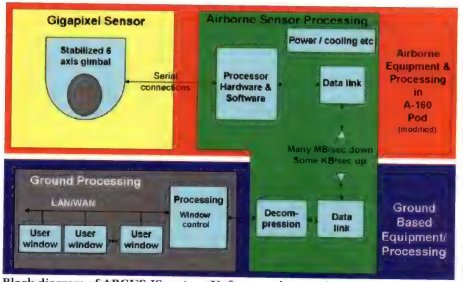
in the image, corresponding to the four sides of the chip edges.

This problem was solved by using not one but four CFPAs, each containing 92 5-megapixel sensors which are combined make up to 368 sensors mentioned above. These four arrays are arranged so that there is overlap with the blank areas of the other arrays so that 100% coverage is achieved. This provides a seamless image mosaic with no operator intervention required.

Naturally, there would have been significant engineering challenges to get all these chips correctly aligned.

Analysing the data

ARGUS-IS generates a staggering amount of data – up to several terabytes per minute in fact. This creates serious challenges to transmit, store, manage and process in order to extract meaningful information. It is simply not feasible for people to review the recorded video data because of the large amount of data continually being acquired. In fact, this surveillance technology has exceeded the ability to use all the data generated.



Block diagram of ARGUS-IS system. Unfortunately, very few technical details have been released about the system but there is some fascinating engineering commentary based on what few facts are publicly known, along with some intelligent guesses, at http://ambivalentengineer.blogspot.com.au/2012/08/argus-is.html

With ARGUS-IS, it is easily possible to generate petabytes (one petabyte is 1000 terabytes) of data every day. At the moment, the world's largest hard drive is Western Digital's helium-filled 10-terabyte model, so a few hundred of these would be needed to store all the data that might be generated in just one day.

Somehow the huge amount of raw video data must be analysed and turned into knowledge. Furthermore, the data must be reduced to a reason-

Civilian Gigapixel Imagery

The first gigapixel digital stitched image was thought to have be made by a hobbyist in 2003. The web page for this achievement is at http://www.tawbaware.com/maxlyons/gigapixel.htm

The image generated was made up from 196 individual pictures taken with a 6-megapixel digital camera. Interestingly, this is not greatly different from ARGUS-IS imagery which effectively has 368 individual pictures taken using 5-megapixel cameras.

Civilian gigapixel imaging projects are becoming very popular. Just Google "gigapixel photography" and you will see the large number of projects and companies involved with this exciting new era of photography. Such images are becoming known as "gigapans". Note, however, that these images are generated by hundreds of smaller stitched images from regular cameras. ARGUS-IS generates 1.8-gigapixel images natively with a single photograph (or more correctly, frame of a video image).

The largest stitched image currently in existence is a 681-gigapixel image of the Moon taken over a four year period. You can see the zoomable image for yourself at http://lroc.sese.asu.edu/images/gigapan/

Also of interest is the Seattle Gigapixel ArtZoom project which was sponsored by Microsoft and celebrates the arts in Seattle, Washington, USA. It's in the form of an interactive image at http://gigapixelartzoom.com/ Terapixel images have also been created.

You can make your own gigapan images. Just Google "make your own gigapan" to see the large amount of equipment, websites and software to assist in doing this. One of the most basic pieces of equipment is an automated mount to automatically incrementally move a camera in various pan and tilt directions in order to cover a scene.

This rendering of the ARGUS-IS imaging head shows the four lenses associated with the composite focal plane arrays and the 6-axis gimbal mechanism.

able size since it might be stored for days, months or years.

This is done using an advanced software suite known as "Persistics", developed by the Lawrence Livermore National Laboratory in the USA under a DARPA contract. Perisistics takes the data stream from ARGUS-IS (or other surveillance platforms) and extracts relevant information such as the movement of people (or "dismounts", in military jargon) and vehicles. At the same time, it compresses non-changing background information, such as stationary objects or geographical features, by up to 1000 times. No data is lost with this approach and indeed, sub-pixel resolution can be achieved for either background objects or moving people or vehicles. For ARGUS-IS, a pixel corresponds to an area on the ground of from less than one square metre to several square metres.

The Persistics software suite can not only operate in near real-time mode but also in "forensics" mode where past data is analysed to detect the precursors to an adverse event. For example, in the event of a terrorist act, the video can be reversed to establish the original location of the terrorists who conducted the act.

Persistics also employs advanced analysis algorithms that enable it to "stare" at people and vehicles of interest for extended periods of time and thus automatically detect anomalies that the system might be programmed to look for. For example, a person of interest might deviate from a regular route and drive somewhere that they might not normally go. This behaviour could be detected, tracked and an alarm issued to the system's operators.

A preselected target of interest can also be programmed into the system and an alert issued if the person or vehicle is found. And thousands of targets of interest over a 100km^2 area can be simultaneously tracked.

The advanced algorithms used in the

ARGUS-IS data can be processed to generate 3D models of areas of interest.

A typical imaging result from ARGUS-IS taken over Quantico, Virginia, USA. The central image is the 1.8 gigapixel picture and each of the small inset windows (except for the top left image and the helicopter) represents an area of interest that is a zoom of the high resolution image. The top left image is the general area on Google Earth, with the dark mosaic image in the centre of the diagram representing the ARGUS-IS picture. The helicopter at bottom left is a Blackhawk carrying an ARGUS-IS pod. To give a rough idea of the size of such an image, assuming this was a square image (which it isn't, but we are approximating) it would be 42,426 x 42,426 pixels. In the central ARGUS-IS image, the contribution of the individual sensing elements can be seen and is evident from the slight brightness variations at their edges.

data analysis make extensive use of another consumer item – high-powered graphics chips (GPUs), as fitted to PCs for computer games. These are used because of their ability to quickly process large amounts of graphics data. Some of the processing power is used to detect and compress non-changing data, while the remainder is used to find and analyse targets of interest.

Before Persistics software can analyse the received video, it must first pre-process the imagery. A technique known as "pixel-level dense image correspondence" is used to carry out the following steps:

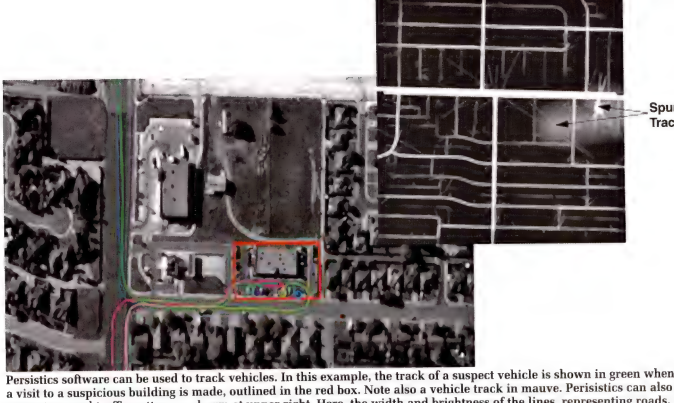
- Stabilise the video to remove the effects of vibration by the platform that acquired it;
- Remove or account for any parallax errors due to processing images from multiple passes by a surveillance platform providing a "straight down" view, thus making it much easier to identify moving targets of interest;
- Compress non-changing background imagery;
- Detect moving people or vehicles of interest and provide sub-pixel resolution of such objects;
- Provide seamless stitching of adjacent images taken by different cameras to make a large virtual image;
- Improve signal to noise ratio; and
- Account for exposure variations on different parts of the image or due to the use of different cameras

Persistics can also automatically apply computing power where it is needed. For example, the software might detect a moving enemy convoy and devote extra resources to tracking that, or it might observe an area surrounding friendly troops to detect any nearby threats. The data can be integrated with existing maps and other metadata of interest.

Questions & answers

Examples of questions that Persistics might answer include:

- Where was a particular vehicle between 10am and 11am this morning?
- What vehicles and people visited this building in the last eight hours?
- What places has this person visited in the last two days?
- What are the origins of the group of vehicles assembled at this location?
- Over the last four weeks, how often



Persistics software can be used to track vehicles. In this example, the track of a suspect vehicle is shown in green when a visit to a suspicious building is made, outlined in the red box. Note also a vehicle track in mauve. Perisistics can also generate a road traffic pattern as shown at upper right. Here, the width and brightness of the lines, representing roads, is shown in proportion to the traffic flow observed. Any deviation from regular patterns of traffic flow might constitute an anomaly that requires further investigation. The spurious tracks shown are errors generated by unusual sun angles and other causes. Showing individual vehicle tracks is an effective means of data compression. Apart from it being easy for an analyst to see, a conventional view of a vehicle of interest would not provide direct track information and would constitute hundreds of individual pictures with only the position of the vehicle changing a small amount between images.

did the person living at this location visit this suspicious building?

- What time does this person normally leave their house in the morning?
- What persons or vehicles previously visited the location of a terrorist attack?

As a result of this, direct relationships and patterns of activities can be established between people, vehicles, buildings, events, times and locations. Also, since everything is recorded and archived, patterns of activity can be established, even for people not currently under suspicion if it is later determined that they were involved in terrorist or other enemy activity.

Unfortunately, no video of the Persistics/ARGUS-IS ability to track people seems to have ever been released. Instead, these are just a few still images but some sense of what might be possible can be gained from a video released of the VIRAT System (Video and Image Retrieval and Analysis Tool) – see http://youtu.be/LkueCrzzRrk or the YouTube title "DARPA Video and Image Retrieval and Analysis Tool (VIRAT)".

Table 1: VIRAT Detection Tasks

INTERACTION	ACTIVITY TO BE DETECTED
Single Person	Digging, loitering, picking up, throwing, exploding/burning, carrying, shooting, launching, walking, limping, running, kicking, smoking, gesturing.
Person-Person	Following, meeting, gathering, moving as a group, dispersing, shaking hands, kissing, exchanging objects, kicking, carrying together.
Person-Vehicle	Driving, getting-in (out), loading (unloading), opening (closing) boot, crawling under car, breaking window, shooting/launching, exploding/burning, dropping off, picking up.
Person-Facility	Entering (exiting), standing, waiting at checkpoint, evading checkpoint, climbing atop, passing through gate, dropping off.
Vehicle	Accelerating (decelerating), turning, stopping, overtaking/passing, exploding/burning, discharging, shooting, moving together, forming into convoys, maintaining distance.
Other	VIP activities (convoy, parade, receiving line, troop formation, speaking to crowds), riding/leading animal, bicycling.

VIRAT might be considered as a companion software suite to ARGUS-IS and Persistics and could be used to scan through data from ARGUS-IS and other surveillance platforms. VIRAT is intended specifically to automatically look for suspicious types of behaviour which Persistics does not currently do. From the original program documentation for the project (BAA08-20), VIRAT ideally looks for the types of activities listed in Table 1.

In short, VIRAT looks for short-term activities which might be suspicious in small geographic areas. For a bigger picture, there is PerSEAS or "Persistent Stare Exploitation and Analysis System". This system also looks for suspicious patterns of behaviour but over a larger geographical area and over much longer periods of time to detect possible threats. Algorithms from VIRAT provide some of the underlying capabilities within PerSEAS.

The US military is not the only organisation that's interested in the data provided by Persistics, VIRAT, PerSEAS and ARGUS-IS. Agencies such as the Department of Homeland Security also have an interest and the data can also be used to check compliance with international nuclear trea-

Table 2: Summary Of ARGUS-IS Features*

FEATURE	CAPABILITY
Number of video windows	More than 100 user-defined windows can be simultaneously observed by operators.
Video tracking	System can track "dismounts" (people) or vehicles as chosen by the operator, or system can initiate automated tracking.
Full field-of-view (FOV) vehicle motion detection	Automated moving target indicators over the full 60° field of view.
Forensic archive	2.5-3.3 frames of effectively lossless JPEG2000 archive in standard NITF metadata.
Unmanned-air-systems compatible	Size, weight, power and function compatible with unmanned or manned fixed wing, rotary and airship platforms.
Archive access	Real-time forensic reach back capability; thumbnails and metadata for ~40,000 targets.
Full FOV mosaics	Calibrated and stitched full FOV mosaic at user-defined update rate for background context.
Gimbal assembly	Six axis stabilised.
Focal plane array assembly	4-colour Bayer CFPA, each containing 92 x 5-megapixel 2.2µm pixel focal plane arrays.
Interface	Data access and retrieval through services provides a standard web-service interface.

* From BAE Systems brochure.

ties by monitoring buildings where suspicious activities might be taking place. Other obvious uses for this technology include border protection and safeguarding important infrastructure such as power plants.

Future developments

Methods of analysing patterns of behaviour that are outside the bounds of established cultural or social norms, and which might indicate possible terrorist activity, are also under development. Research is also under way to use Persistics data to develop 3D models of areas of interest. The companion data analysis suites VIRAT and PerSEAS will also continue development.

YouTube Video

A YouTube video of the ARGUS-IS system, titled "Spy Drone Can See What You are Wearing From 17,500 Feet", is available at http://youtu.be/AHrZgS-Gvi4 This is an extract from the Nova program "Rise of the Drones" (released on PBS Jan 23, 2013) which can be seen at http://youtu.be/I0zCiCI05Ec

On the hardware side, an infrared version of ARGUS is also under development, designated ARGUS-IR. ARGUS-IR is another DARPA-funded project and is designed to address the problem of current IR sensors which have a narrow field of view, limited resolution and a low frame rate.

ARGUS-IR will operate much like ARGUS-IS, the objective being to track unmounted targets at night. It will use at least 130 independent video streams for tracking individual targets of interest. The concept will be similar to ARGUS-IS in that it will use many smaller sensors formed into one large virtual sensor mosaic.

Civil liberties concerns

Some civil liberties groups in the USA have expressed concern that this technology might be used to monitor American civilians. In particular, the activities of civilians could be recorded and archived by the government, even if they have done nothing wrong.

At the moment, ARGUS-IS is not used in any civilian environment in the USA. However, amid much controversy, the technique of Wide Area Persistent Surveillance is under consideration for use in Dayton, Ohio.

Conclusion

ARGUS-IS represents an exciting new technology for use in intelligence gathering and the fight against global terrorism. However, the ability to "see all and know all" also has potential civil liberties concerns if the technology is used inappropriately by governments, so it is important that people know this technology exists and understand what it can do.

To their credit, the US Government did make information on ARGUS-IS known to the general public and it is up to all free people to ensure it is only used for its intended purpose. SC

MOVIES ON A STICK

Home viewing has never been so much a jungle as now. In most capital cities, there are now 17 free-to-air channels, with some broadcasters running duplicate programming on some of these with, no doubt, plans to utilise each later for 'special purposes'.

In this forest of options there are also shopping channels, an indigenous broadcaster and a community channel (whose future is definitely under a cloud). And of course, there's an avalanche of programming waiting for you on Pay TV sites. Viewer heaven? Not quite!

Back in the 1990s some wit said of US cable television: "500 channels and nothing to watch!"

Well, the truth is that there's plenty to watch on Australian free-to-air television but the majority of current television programming would send an insomniac to sleep!

Many of us resort to hiring DVDs to exert a modicum of personal choice. But even there, video rental shops are facing extinction as people become too lazy to pop down the road and pick up a movie, or find the pay-per-view options on their pay TV channels offer a 'good enough' choice.

If they're any good, movies are only released to DVD or pay-per-view some months or so after the cinema screenings.

The solution to this is to access programming yourself and replay it on the home TV and play it when you want to!

One way to achieve this is to acquire a Personal Video Recorder (PVR), which I did recently. This has been a boon to viewing at will, with Full-HD quality enjoyable on a large (HD) screen.

I then found an additional, relatively simple and cost effective solution that not only gave my family a multitude of viewing choices but allowed viewing at any hour or day of programming that we really wanted to watch.

by Barrie Smith

And if we really enjoyed a particular movie/program, we could watch it again . . . and again . . . and again!

It all began when I discovered that two of our home TVs looked like they could accept a USB stick (aka flash drive or thumb drive) that could run movie files downloaded from the Internet. But no luck.

The first (5-year old) TV did have a USB port but appeared to employ the USB port only for system updates; most current "smart TVs" have USB and SD card slots so, if you're in a buying mode, check out the TVs in your local store.

Moving to the Panasonic PVR I found that this had not only a USB port but also provided an SD card slot, with the former doubling as an external hard drive port.

Grabbing a handful of sticks and an SD card or two I swung over to the YouTube site on my computer and with the aid of some streaming software, loaded up the sticks and the cards with a handful of silent movies (one of my faves) and galloped back to the TV and PVR.

Success . . . to a degree. Some of the movie files would not play, some faltered or froze. But some did! I'll discuss this situation later.

However, I still faced the challenge of running my movies (and not the broadcasters') on the second TV. What to do?

Roaming around eBay and various retail

sites I discovered a breed of device called a media player which seemed to answer my needs.

Kaiser Baas HD Media Hub

The Media Hub looked like the legendary 'black box', hardly larger than a pack of cards. It had all the input and output slots for my needs: two USB slots that would accept flash drives (or an external hard drive); an SD/MMC slot to take a card; plus audio outputs. Output to theTV was via HDMI.

And all this for $58 at my local electronics retailer!

Then I fell into a well of techno terror.

A month or so after I started my adventure with the unit I fell foul of the Setup button which adjusts the settings of the media hub. My first fumble was to fool around with the Language button; this led to my locking the entire unit into Chinese script! What to do?

Luckily, I found the Kaiser Bass help site (http://kaiserbaas.helpserve.com/Knowledgebase/List) and quickly got the unit back to English.

A day or so later, in a lazy moment, I approached the Setup button and activated the button which promised to restore the unit's default setting — just out of curiosity. This of course completely "bricked" the unit!

Back to the retailer. . . swap for a new one . . . take it home and get it going. . . and continued my tour — with careful avoidance of the Setup button!

The KB performed OK, running my movies, early TV programs, the occasional MP3 tracks and some family photos. Then this one went down the well too, never to return!

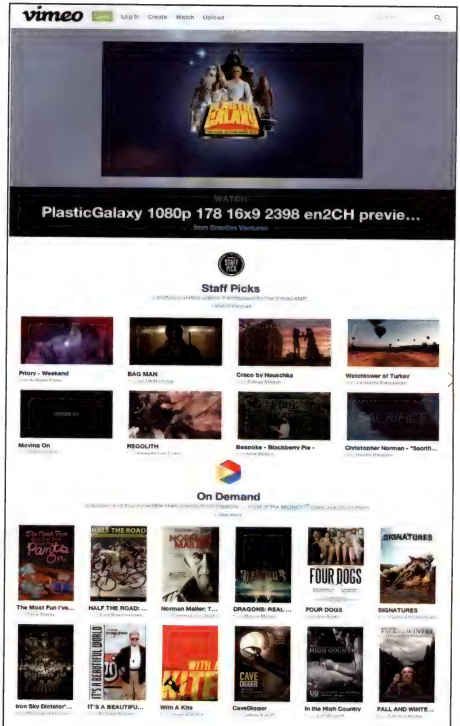
At this point I spoke to the Melbourne agent's point man and discovered that my unit was to be superseded shortly by a new model which promised to fix all my woes. So if you're going to buy the unit, make sure you get the new model. They're visually quite different.

Kaiser Baas HD Media Hub Plus

Note the Plus! This new black box, sized to the equivalent of two playing card packs, has a tiny blue 'on' LED at the front and two USB and one memory card slot at the side. You can plug a hard drive into either USB port.

The rear panel has a 5V DC input from the supplied power pack, component (Y, Pb, Pr) and composite outputs, a stereo audio output and an HDMI output.

The remote control has 27 keys, including an OK button and four directional arrows. The text on some is tiny, about 2mm in height — so get out the reading glasses!



Vimeo is a US-based site that has movies and TV series for downloading. Popular titles are listed first but searching will reveal thousands more.

On startup we view a row of icons: File Manager, Movie, Photos, Setup etc. If you want to play a movie, some JPEG stills or MP3 tracks, the device is clever enough to sense what files are where, whether they're stored on USB stick, SD card or hard drive.

Tap "Movie" and you select which media (USB1, USB2, card or hard drive) is holding your file. Next is a text list of the files on your chosen media.

The whole process is graphically displayed and easy to navigate. Tap your selected title and in seconds, up comes the show.

My first Kaiser Baas Media Hub. It worked fine at first, then developed significant problems. I took it back!

The range of control on the remote is exceptional: audio levels, brightness etc; vary the screen proportions (4:3, 16:9, pan & scan etc); scan fast forward/reverse/freeze; return to the previous function and so on.

I have come across the odd title that has vision & sound out of sync. The KB unit has an audio sync corrector; it has plus and minus variations of up to 9 milliseconds.

But I found this was not enough to do the trick on a suspect movie. Obviously it needs more than 9ms adjustment (that's not real long!).

Supplied with the unit are a power adaptor, remote control, warranty card, user guide, quick start guide, 2 AAA batteries and HDMI cable. Be careful of the last item: with some models, it's a rather expensive "option".

Overall, I was delighted with the gear. It performed with great aplomb.

First catch a movie

As Mrs Beaton is famously supposed to have once said "first catch your hare" (she didn't, but that's apocrypha for you) you need to first "catch" your movies. So go and get some video for your player.

Start at www.youtube.com. Type in "Laurel and Hardy" and up comes a list of their early comedies, some silent, some with sound with varying running times. Top of the YouTube list is Liberty, an early sound short running 17m 57s.

Next step is to download Liberty.

Unless your computer came preloaded with appropriate software, you cannot simply download and store video from YouTube – you need some software application to perform the task for you.

There are many – some are commercial while some are freeware. Early on I tried a paid app: Wondershare Free YouTube Downloader.

The newer Kaiser Baas Plus Media Hub. This one has proven to be a reliable, a really great performer and I highly recommend it!

For Mac: (www.wondershare.com/pro/mac-free-youtube-downloader.html) and for Windows: (http://wondershare-video-converterultimate-win.en.softonic.com).

This worked fine for a month or two, then failed. Luckily, I managed to extract a refund from the developer.

I have since used the freeware RealPlayer Downloader (now renamed RealPlayer Cloud) and found at www.real.com/realplayer/cloud/international. Then there's 'Final Video Downloader' for Windows (www.finalvideodownloader.com). And there are quite a few others.

My choice is YTD Video Downloader freeware, found at www.ytddownloader.com/mac/ This is for Mac users. Windows fans can head for http://ytd-video-downloader.en.softonic.com/download

The Mac version I can swear by but I have not tried the Windows flavour.

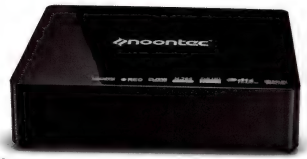
YTD Video Downloader is much more than a mere downloader. You begin by pasting the URL (with Liberty, for example, it is www.youtube.com/watch?v=cyKRNCWZN8&spfreload=1) into the software's panel.

You select the destination on your computer... I chose Desktop. Then you simply tap the Download button and away it goes. The default format is MPEG4 but there are other options, such as QuickTime Movie, WMV etc. It works like a dream.

Once downloaded, you simply copy the MPEG4 file to a USB stick or SD card and slip it into the Kaiser Baas player.

Early on you'll find that a cheap 2GB USB stick will suffice but when your enjoyment and ambitions expand, I suggest you pick up a larger stick.

Just one of the many menu screens on the Kaiser Bass Media Player. It has clear graphics to guide you through its operations.



There are many other "media centres" on the market, with a wide range of prices and features. On the left is one of the 'Noontec' range available from Altronics (www.altronics.com.au). The $59.95 Edimax 1B CV-7428nS from Jaycar (www.jaycar.com.au) also sports WiFi.

Some full movies at the full resolution of 1080p can soak up nearly 2GB. A half hour TV program like The Twilight Zone can account for nearly 500MB at full res.

Of course with a big fat hard drive you're really cooking with gas.

On the matter of what format to save your USB movie in I have found that, on occasions, I have needed to convert the clip to other formats, like AVI, QuickTime Movie, MKV, FLV and others.

The whole format thing is a can of worms which could form another story in this magazine!

This conversion can be achieved with YTD Video Downloader or other apps like FLV Crunch for Mac or Windows (http://flv-crunch-mac.en.softonic.com/mac/download and http://free-flv-converter.en.softonic.com).

On occasions you'll find the audio and video are out of sync. You can use a third party video editor like Windows Movie Maker or iMovie (Mac) to change the relative length of your audio or video tracks.

Downloading this content and more particularly, anything with a strong audio content, can lead to other avenues. For instance: you download an MPEG4 file of say, a concert

YOUR CHOICE – and it is ENORMOUS!

The world of movies and TV shows is only a mouse-click away!

It really is extraordinary how much top material is out there, just waiting for you to discover and feed it to your media player.

In my own case I started out with a

large dose of the 50s/60s TV series The Twilight Zone, hosted and mostly written by the master talent, Rod Serling. These are quite extraordinary in their originality and production values. Some are a half hour in length, some a full hour. Many of the players were newcomers to the small screen ... like Dennis Hopper, Burgess Meredith, Jack Klugman, William Shatner, Keenan and Ed Wynn, Robert Duvall etc.

Regarding copyright of Twilight Zone, I discovered that the production company failed to renew copyright in the original series.

Another in my collection is The General, a classic silent comedy film made in 1926 and starring Buster Keaton.

Then there's Monty Python, the Two Ronnies series, Dad's Army, early classics such as Nosferatu (1922), an early Jekyll & Hyde movie, recent action films starring Arnold Schwarzenegger, Jean-Claude van Damme and others.

Australian films are there, of course: The

Tunnel (2011), The Odd Angry Shot (1979), FJ Holden (1977) and many others.

I have Chinese classics: Farewell My Concubine (1993), Yellow Earth (1984) and others plus British, French, Swedish, American classics. There's even the odd Disney title!

You'd be surprised what you can find – and they're all there for your USB stick, SD card, external hard drive and the media player.

Western Digital's UNMI Video Streaming Player supports a wide variety of entertainment options. It has built-in WiFi and Ethernet connectivity for high-speed Internet access so is ideal for streaming services.

that runs for an hour and convert it to an MP3 audio file. Most current car radios can play audio from a USB stick. Or you could convert the MP3 to a CD for home use.

Vimeo

Don't ignore Vimeo (**http://vimeo.com/watch**)

This is a US-based video-sharing website on which users can upload, share and view videos. Not only will you find movies and TV series but the site holds many, many home-made versions of the title you're searching for.

Netflix

There are a few ways to watch Netflix, bearing in mind that Australian viewers are normally blocked from doing so. As a subscription service, ABC News informs "Netflix charges a fee to watch television series and movies ad-free and now has 50 million digital subscribers in the Americas and some parts of Europe".

The company also produces original television content, including "House Of Cards" and "Orange Is The New Black."

It's expected that Netflix may land in Oz some time in early 2015. In the meantime ABC News estimates that "as many as 200,000 people are getting around the geoblock to sign up." Geoblocks are simply a means of stopping you downloading content from certain areas to other areas (eg, USA to Australia!). They're not particularly difficult to bypass. One way is to head for **www.netflixaustralianow.com.au/netflix/netflix-in-australia/**

Here you'll also find notes from those who have cracked the geoblock and are currently enjoying the service.

Of course there will be many readers who don't want to go rogue and "illegally" engage Netflix. Another factor is that many of these "cracking" methods call for you to supply your personal credit cards details as well as email address. Personally, I'm very wary of such a situation.

More Players

The Kaiser Baas unit is a device that could expand your viewing options at low cost. Of course, once you start looking around, you will find there are quite a few other media players, some with more features and some with WiFi capabilities.

Kaiser Baas has another model that has WiFi as well as the USB reading feature. It's around $100.

Western Digital's ~$130 Live Streaming Player has two USB ports, an SD card slot and has Wifi connectivity.

Then there's Jaycar and its $59.95 Edimax Wi-Fi Bridge that connects with the Internet and up to five devices, such as games consoles, Bluray players and others.

Altronics market the Moviedock and Noontec ranges of media players.

The $50 Moviedock A3IIS HD Media Player supports USB, HD and cards plus an Internet link, while the $86.50 Moviedock A3S HD Media Player has slots for USB sticks and SD/MMC cards.

Altronics' Noontec $50 NAS Media Centre Gigalink unit offers hard drive support as well as USB sticks and the $95 Noontec V7S HD model offers a USB port, card slot and external hard drive connectivity. The Noontec A6S model has similar specs and costs $115.

The Noontec V972 Dual Tuner HD PVR takes the game further, with an in-built dual tuner, HD support, USB and card slots and WiFi and retails for $199.

The $149 Noontec V9S model has slots for hard drive and USB slots.

PIRACY, ILLEGAL DOWNLOADS AND COPYRIGHT – WHERE DO YOU STAND?

You often see comment about "piracy", "copyright" and "illegal downloads" raised in the popular press, particularly where new movies (some not even released in Australia) or popular TV series (held back in Australia mainly for ratings purposes) are downloaded from overseas via the net.

But what makes these downloads illegal?

It must be understood that the owners of the film or program, or those who are licenced to release it locally, have quite clearly-defined rights under copyright law.

If they want to geographically restrict distribution or even withhold availability completely, they are perfectly within their rights to do so.

Even if the film or program on the net which you can get access has been placed there legitimately (unlikely – it has quite possibly been sourced illegally) you are breaking copyright – and the law – if the owner says you can't download it.

There is no excuse under copyright law for those who say "well, it shouldn't have been held back here because people have a right to watch it". No they don't, not if the owner or licencee say they don't! The owners/distributors have every right to do what they want – it's their property!

There is no real difference in bringing a DVD of an unreleased movie back from overseas and making copies to flog off at markets, online, etc. It is illegal!

Downloading from paid sources (part of the fee you pay goes to the owners) or from archives where copyright has expired or has been released is quite a different matter – and this is what this article is all about.

As far as sites like "YouTube" are concerened, it's a bit hit-and-miss.

While a lot of content is uploaded by commercial organisations as part of their marketing efforts, a huge variety of content is actually copyrighted material and strictly speaking, shouldn't be there.

Much of it has been uploaded by (well-meaning?) YouTubers without any permission to do so.

The fact that you *can* download something from a website does not imply that you legally *may*! SC

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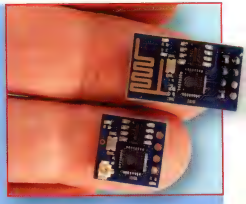
Leave this page where it can be 'accidentally` spotted!

The $5 WiFi Server

By Geoff Graham



This is something that you will find hard to believe . . . a WiFi module which includes the 2.4GHz transmitter and receiver, the aerial, a full TCP/IP protocol stack, a web server and everything else that you need to add wireless Internet connectivity to your next Micromite or microcontroller project. And it costs just $5!

LOW-COST WiFi modules based on the ESP8266 chip are now available from the Chinese company Espressif Systems Inc. These modules can be purchased from many suppliers on eBay and other sites on the Internet for prices ranging from $4 to $6; and that often includes free postage or freight.

The ESP8266 module connects to your microcontroller via a serial link and can be used to serve up web pages, send data to Internet services like Twitter, send emails and so on. So for a very small outlay, you can add a sophisticated level of communications to your next project.

The ESP8266 itself is an impressive little chip. It measures just 5 x 5mm and contains a complete WiFi transceiver including the transmitter, receiver, integrated TR switch, balun, low-noise receiver, power amplifier and matching antenna network. It meets the requirements of the 802.11 b/g/n standards, including full encryption, so it will easily integrate with your current network.

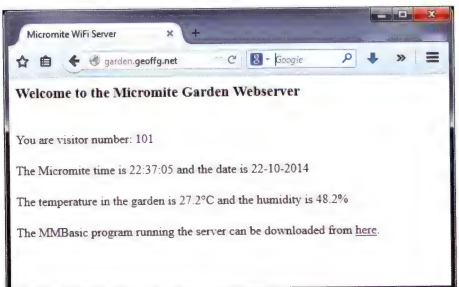


Fig.1: you should receive something like this if you connect to our "Micromite Garden Webserver" using the URL: http://garden.geoffg.net It gives you the time according to the server's internal clock and the current temperature and humidity. It is intended as a demonstration of what you can do using the Micromite and an ESP8266 module.

The ESP8266 needs very few external components. The reference design requires just three capacitors, one resistor, a flash memory chip and a 24MHz crystal. Many suppliers in China have fully-built modules using this design and all you need to do is connect the module to your microcontroller and supply power.

In addition to the WiFi transceiver, the chip also houses a 32-bit processor which is used to run the TCP/IP protocol stack. This includes high level Internet protocols such a web (HTTP) server, P2P Wi-Fi Direct, infrastructure base station mode and softAP mode.

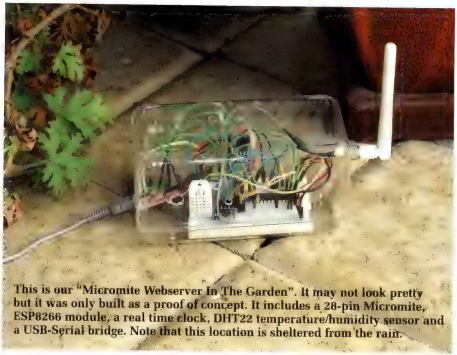
The ESP8266 is intended to capitalise on the Internet-of-Things (IoT) concept which posits that everything, from the smallest gadget to the largest appliance, will in future be connected to the Internet in some way.

For the ordinary experimenter it opens up a world where easy connectivity to the Internet is well within reach.

Micromite in the garden

As a demonstration of what you can do with this module we have placed a Micromite and an ESP8266 module in a garden. This monitors the current temperature and humidity in the garden and serves this data as a web page via WiFi to an access point and then via a router to the Internet.

It is only a simple example but if you would like to see the output of a combined Micromite and ESP8266

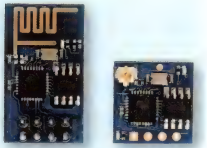


This is our "Micromite Webserver In The Garden". It may not look pretty but it was only built as a proof of concept. It includes a 28-pin Micromite, ESP8266 module, a real time clock, DHT22 temperature/humidity sensor and a USB-Serial bridge. Note that this location is sheltered from the rain.

web server, you can connect to our demonstration server by entering the following URL into the address bar of your browser: http://garden.geoffg.net You should receive a web page as shown in Fig.1.

The program running on the Micromite uses a combined temperature/humidity sensor along with a real-time clock and is a good demonstration of how to implement a web server using the ESP8266 module. The full MMBasic program is available for download from the SILICON CHIP website and if you intend to implement a web server it would make an excellent starting point.

The Micromite was featured in the May 2014 issue of SILICON CHIP. In case you missed that issue, the Micromite is a single 28-pin or 44-pin microcontroller that runs a powerful BASIC interpreter. You can control up to 33 I/O pins and communicate with other chips using I^2C, serial, SPI and other protocols. In this case, communication with the ESP8266 is via standard serial.



These modules are tiny but they pack a punch. They include the WiFi transmitter and receiver, antenna switching and matching network, WiFi 802.11 a/b/n compatibility, a TCP/IP protocol stack and a web server. When connected to a microcontroller you can serve web pages, send emails and log data onto "the cloud". The larger unit has the antenna on the PCB while the smaller unit uses an external antenna. Note: modules shown larger than life size.

Module variations

There are a many versions of the ESP8266 module in circulation. The most common is illustrated in Fig.2. It has eight connections which include power, serial transmit/receive, a Power Down pin, a Reset pin and two general purpose input/output pins. This module includes its own aerial etched onto the PCB and this feature makes it quite easy to work with.

The only issue with this module is that the arrangement of the connecting pins makes it impossible to plug it into a standard solderless breadboard. So you will need to solder wires to the pins or use jumper leads to connect to a breadboard.

Another common version is illustrated in Fig.3. This has just four connecting pins (two for the power and two for the serial interface). Fortunately, these pins have a 0.1-inch spacing which is breadboard friendly.

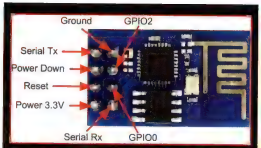


Fig.2: these are the connections to the most common version of the ESP8266 module which has an on-board antenna. Note that not all modules have the Power Down and Reset pins connected (this mostly applies to older versions of the module).

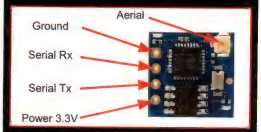


Fig.3: this diagram shows the connections to the version of the ESP8266 module without an inbuilt antenna. The antenna connection is via a miniature U.FL connector and these are common in WiFi access points and routers that employ an externally mounted antenna (you may be able to salvage these parts from an old WiFi router or modem).

The module is intended for use with an external aerial and there is a miniature U.FL connector on the board for this purpose (also referred to as an IPEX, IPAX, IPX, MHF, UMCC or AMC type connector).

Suitable aerials can be purchased on eBay and the U.FL connector is common in WiFi access points and routers that employ externally mounted aerials – so you may be able to salvage a complete aerial and connector from a discarded access point. As you would expect, with a decent antenna, this module has a far greater range than the version with a PCB antenna.

There are other variations of the ESP8266 module with different connecting pads but the above two are the most common

The good & the bad

The ESP8266 modules on offer are quite powerful but they do come with some issues (or perhaps we should say "challenges"). The ESP8266 chip itself is mostly documented in Chinese.

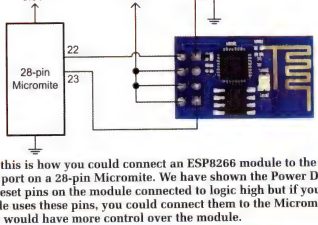


Fig.4: this is how you could connect an ESP8266 module to the COM1 serial port on a 28-pin Micromite. We have shown the Power Down and Reset pins on the module connected to logic high but if your module uses these pins, you could connect them to the Micromite so that it would have more control over the module.

There are some (translated) English data sheets but in general they are brief and do not tell the full story.

The firmware (TCP/IP, server, etc) that runs on the 32-bit processor integrated on the chip is what most users will interact with and unfortunately this is also poorly documented.

As a result you will need to be adept at trawling the internet and discovering facts and techniques that others have painfully learnt. Hopefully, what we have to tell you in the following pages will also make that task somewhat easier.

You should also refer to the side panels. One lists some of the more relevant commands recognised by the module and the other lists relevant ESP8266 websites where you can find much more information.

Connecting up

The ESP8266 requires a well-regulated 3.3V supply and it can draw quite a lot of current, especially in transmit mode. Normally, the current requirement varies from 10-70mA when the module is idling or just receiving but it can jump to over 200mA during transmit. So a solid 3.3V 300mA supply is a must.

The module has a serial interface running at 115,200 baud with the standard settings (eight bits of data, one stop bit and no parity). This is a TTL level signal (idle is voltage high) and it uses 3.3V signalling levels. These perfectly match the Micromite's COM1 serial port so the two make a great pair.

Do not try to connect the ESP8266 module to a microcontroller running at 5V or to an RS232 interface without a level translator. The voltages on these interfaces will exceed 3.3V and could easily destroy your module.

Controlling the ESP8266

To control the operation of the ESP8266 module, the microcontroller will need to send commands over the serial link and will receive acknowledgements and data in return.

Communicating is straightforward; all commands sent from the microcontroller begin with the letters "AT" and the module replies with "OK" or "ERROR" or the data that you have requested (rather like the Hayes modems in the past).

The Tx (transmit) pin on the module should connect to the Rx (receive) pin on the microcontroller and Rx on the module should connect to Tx on the microcontroller. The Reset and Power Down pins (if your module has them) should be connected to the 3.3V supply. The other (general purpose) pins can be left unconnected.

Fig.4 illustrates a typical connection for the 28-pin Micromite. Note that older versions of the module leave the Power Down or Reset pins unconnected or use them for general purpose I/O – so you may need to experiment with these two connections (see the accompanying panel for a website that identifies the differences).

If your module does have a Power Down pin, it is important that this pin is pulled high by connecting it to the power (3.3V) pin. If it is left floating, the module will power down by default.

For the purpose of experimentation you can connect the module via a USB-to-Serial bridge and type in commands directly from your computer.

First steps

In the following discussion, we will avoid listing a lot of programming code. Not only is it boring but it is also much easier to download a program than to type it in. The main program that you will want to refer to is our example of a web server running on the Micromite (in the garden!). This can be downloaded from the SILICON CHIP website.

In order to get started with the ESP8266, you need to type in some commands and observe the result. If you are using the Micromite, the easiest way to do this is to use the small program shown in Fig.5. This will turn your Micromite into a simple terminal where anything that you type into the Micromite will be sent to the ESP8266 module and anything it sends back will be sent out from the console to your screen.

When you first apply power to the ESP8266 module, the current should jump to about 67mA while the module sniffs the air and then drop down to 10-30mA. Run the terminal program on your Micromite (or connect in some other way) and try typing in:

```
AT
```

When you hit Enter, the module should return with OK. This is a big step and once you are communicating you can get on with testing how the module will respond to your commands.

By the way, all commands should be in upper case, should not contain any

spaces and are all terminated by the Enter key. If you enter an invalid command the module will respond with ERROR, otherwise you should see OK.

The next stage is to tell the module to act as both a client and access point. The command is:

AT+CWMODE=3

The module should reply with a simple OK.

Then you need to reset the module. Why you need to do this is uncertain and not documented but we have found that it is a necessary step.

You reset the module with the command:

AT+RST

You should get an OK followed by a dump of data half a second later. You can ignore this data as it just lists details of the firmware running on the module.

At this point you can do some useful things. For example, try listing the WiFi access points in your area. The command is AT+CWLAP and in return you will get something like this:

```
+CWLAP:(0,"",0)
+CWLAP:(3,"BigPond9B8A1D",-86)
+CWLAP:(2,"wifhubs",-85)
+CWLAP:(4,"wifhubs_2GEXT",-77)
+CWLAP:(4,"dlink-281D",-91)
+CWLAP:(4,"Baas DSL-2890AL",-90)
```

In this case the module has sniffed out the WiFi access points in adjacent offices as well as the one we want to connect to.

The first digit after the opening bracket is the security protocol that the access point is using (0 = open, 1 = WEP, etc). The second field is the network name (or SSID) of the access point and the third field is the signal strength.

Connecting to your network

To connect to your WiFi access point, use the following command:

AT+CWJAP="SSID","passwd"

where "SSID" is the broadcast name of your WiFi access point and "passwd" is the password for access. Note that there should not be any spaces and the quotes should be retained as shown. If the connection is made, the module will return with OK. If something has gone wrong, you will receive the message ERROR.

You could experience some difficulty here as the access point might reject the connection. Possible reasons include incorrect case in the SSID or password, the security set-up of the access point (ie, if only certain MAC addresses are permitted access), the inability of the module to get an IP address from the router because the router is not running DHCP or simply the module being too far from the access point.

Once you have connected to your network you can try the command:

AT+CIFSR

This will return with the IP address that your access point assigned to the module, eg, 192.168.0.109. Note that this command is one of only a few that do not return with OK.

To verify that the module is "on the air", you can ping it from your PC. In the case of a Windows computer, you can call up a command window and and enter the ping command and the IP address. As an example, enter the following at the command prompt:

ping 192.168.0.109

You should see the ping packets as they are sent to the module and the

Common Commands Recognised By The ESP8266 Module

AT
Checks that the module is alive. The response should be OK.

AT+RST
Reset the module. It will first respond with OK followed by a dump of information related to the firmware.

AT+GMR
Returns the version number of the firmware.

AT+CWMODE=n
Sets the mode of operation according to the number n. Where 1 is a WiFi client, 2 is an access point and 3 is both client and access point. Note that as an access point the module has limited functionality (no DHCP, etc).

AT+CWLAP
Will list the currently available access points in the location.

AT+CWJAP="SSID","passwd"
Will join a network where SSID is the access point name and passwd is the password. Both must be surrounded by quotes.

AT+CWQAP
Will close the current connection to an access point.

AT+CIFSR
Will return the IP address assigned to the module.

AT+CIPMUX=n
Will configure the module for multiple connections according to the number n. Where 0 is single connection mode and 1 is multiple connections mode.

AT+CIPSERVER=n,nn
Will start a server. If n is 0 if the server is to be disabled or 1 if it is to be enabled. nn is the port number. WEB browsers default to port 80. When a connection is established the module will send "Link" followed by the data offered by the remote browser.

AT+CIPSEND=n,nn
Will send data to a remote client that has connected to the server. n is the id number of the transport connection (normally zero but it can be some other number if two clients have connected simultaneously). nn is the length of the data to send including any terminating carriage return and line feed characters. The module will prompt with ">" then the microcontroller should send the data followed by carriage return and line feed.

AT+CIPCLOSE=n
Close the connection n (normally this is zero). This is should used after all the data has been sent to the client.

Note: most commands acknowledge with OK or ERROR. There are many more commands that the module will recognise. For a full list, consult the links in the side box.

Reference Links For The ESP8266

Home page of Espressif Systems Inc, the designers of the ESP8266:
https://espressif.com/

An English version of the data sheet for the ESP8266 chip:
https://nurdspace.nl/File:ESP8266_Specifications_English.pdf

Description of the module and the commands that it will accept:
http://www.electrodragon.com/w/Wi07c and https://nurdspace.nl/ESP8266

How to tell if your module has a Power Down and a Reset pin:
http://www.xess.com/blog/esp8266-is-alive/

How to update the firmware:
http://blog.electrodragon.com/cloud-updating-your-wi07c-esp8266-now/

A community forum focused on the ESP8266:
http://www.esp8266.com

Search eBay for sellers of modules based on the ESP8266:
http://www.ebay.com/sch/i.html?&_nkw=ESP8266

response times as the module returns the pings.

The module will remember all the previous set-up steps, even when the power is cycled. So, when you next apply power, it will automatically connect to your WiFi access point and get an IP address.

Most access points/routers will try to assign the same address each time your module connects but this is not guaranteed. To ensure that the address of the module doesn't change, you should go into your router set-up and assign a fixed IP address to the module based on its MAC address.

You need to do this because the module does not have a network name, only an IP address and by making sure that this address does not change you will always be able to find it on your network by using the IP address.

Starting the web server

The first stage of setting up a web server is to tell the module to accept multichannel connections. The command is:

AT+CIPMUX=1

The module should reply with a simple OK.

You need to then tell the module to act as a server for port 80, which is the default port used by web browsers. This is done with the AT+CIPSERVER command as follows:

AT+CIPSERVER=1,80

The module will respond with OK then listen for incoming connections on that port number. When a remote computer does make a connection, the module will send a line containing the single word "Link" to the microcontroller.

Following this message, the module will send a series of other lines representing the data transmitted by the remote computer when it connected.

This often includes information identifying the operating system and browser but the important part is a line with the word "GET" followed by a path. The path is the web page that the browser is requesting. A simple "/" means that the browser wants the main WEB page while (for example) "/data.html" means that the browser wants the page called "data.html".

If you only want to offer the one page, you can ignore the details and just send your data back. This is done using the AT+CIPSEND command, as follows:

AT+CIPSEND=n,nn

where n is the channel number and nn is the length of the line of text that will be sent (including the terminating carriage return and line feed characters). The module will respond with ">" which is the prompt to send the actual line of text. When that line has been transmitted, the module will return with: SENT OK

The channel number (n) mentioned above is normally zero but the module can handle up to four simultaneous requests and if that happens you will have to note which request you are responding to and use the correct number for n.

This is a typical send operation

AT+CIPSEND=0,38
> <TITLE>Micromite WiFi Server</TITLE>
SEND OK

You may send as many lines as you wish by using multiple AT+CIPSEND commands. Each line should be formatted according to the html standard so that they will display correctly in the browser.

When you have finished sending the web page, you should close the connection with the command:

AT+CIPCLOSE=n

where n is the channel number.

Rather than go into excessive detail, it will make more sense if you to download the example server code for the "Micromite in the Garden" from the SILICON CHIP website. Using the above discussion as a guide, you can see how a real web server can be implemented.

Restarting the module

One annoying issue that we did run into is that the ESP8266 can get confused for no particular reason and stop communicating. To overcome this, we used a TI TPS2042B power switch to control power to the module. If the module did not respond, the program would turn off power to the ESP8266 for a short time to clear the fault condition. The MMBasic server program would then initialise the module.

Note that if you use this technique, you should also place a 33kΩ resistor in series with the signal going to the module's Rx pin. This is because the microcontroller will still be driving its Tx line at 3.3V when the module is powered down and the resultant current into the module's Rx input will destroy it. The resistor will limit this current to a safe value (100μA).

Alternatively, if you have a module with a Power Down pin, you can achieve the same result by simply connecting this pin to an output pin on the microcontroller and toggling it low for 200ms when you need to restart the module.

It's possible that a more recent version of the firmware for the ESP8266 will fix the bug that causes it to become non-communicative. However, this technique will still be useful because there are many other things that can go wrong and a brief power down will rescue the server regardless of what difficulty it is in.

Beyond a simple web server

You can get quite fancy with your web server if you want to. You could format the data in your web page to include variables that the microcon-

troller is monitoring; eg, temperature, voltages etc.

You can also use html FORM tags to create check boxes, radio buttons and push buttons on the web page. When the user selects these items, their browser will send a message to the ESP8266 module which can be interpreted by your server program to turn on a valve, unlock a door or whatever.

Using html links, you can have hot links in the web page that link to other pages supplied by your microcontroller or other websites.

Nor are you limited to simply serving web pages. Using the ESP8266 module, your microcontroller can get the time from the Internet or the current weather forecast. You can connect to an SMTP server and send emails – eg, to alert you to some fault condition.

You can also connect to services like Twitter to upload and log interesting information – eg, the humidity in your greenhouse. There are also websites that specialise in logging data from embedded controllers. A popular service is **http://thingspeak.com** which will store, graph and present your data for you. Imagine being able to check the temperature trends in your home-brew concoction via your smartphone.

And don't forget that the cost is just $5 for this amazingly capable module.

Upgrading the ESP8266

Most ESP8266 modules come with version 00160901 of the firmware. You can discover the version of your module with the command: AT+GMR

Some talented individuals on the Internet have created alternative versions of the firmware which include bug fixes and extra features such as the ability to change the baud rate. One especially valuable feature is the capability of putting the module into a transparent mode where any data sent by the remote computer is fed straight through to the microcontroller and vice versa.

This means that you can set up an ESP8266 module and connect it to the Micromite's console. Using telnet, you can then connect to the Micromite via WiFi and edit the program running on it – all from your desktop while the Micromite and ESP8266 module are hidden in a cabinet, in your shed or some other inaccessible location.

An accompanying panel contains links to websites that carry upgraded versions of the firmware. To upgrade the module, you need to short one of the GPIO pins to ground and run a program on your computer that will transfer the new firmware via the serial link.

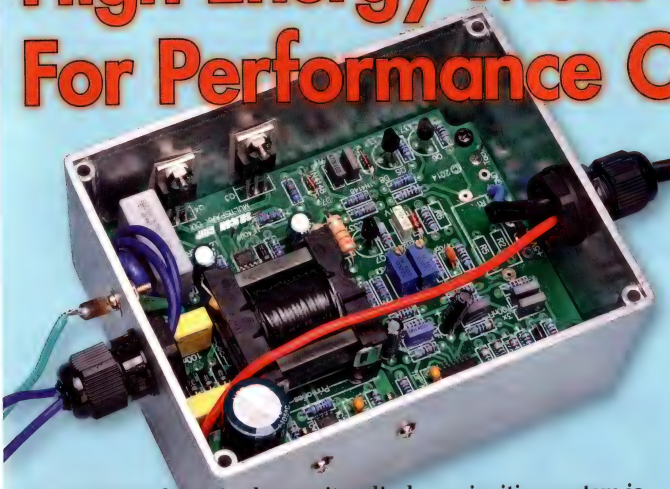
The operation is relatively painless and it only takes a minute or so. About the only downside is that the new commands and features are often poorly documented so you will need to engage in some personal experimentation. SC

Terminal Program

```
OPEN "Com1:115200" AS #1
DO
  PRINT INPUT$(1, #1);
  PRINT #1, INKEY$;
LOOP
```

Fig.5: this simple program will turn your Micromite into a terminal. It will shuffle characters between its console and COM1 (the ESP8266 module) and is useful for experimenting with the module and verifying how it reacts to commands.

High-Energy Multi-S
For Performance Ca



This completely revised capacitor discharge ignition system is designed to provide a very high energy multi-spark discharge each time the spark plug is fired. It enables complete mixture combustion in virtually all internal combustion engines used in cars and motorcycles and is especially effective with engines that run at high RPM.

WHILE FACTORY-DESIGNED ignition systems in modern vehicles operate reliably and give a high-energy spark, there are many situations where a multi-spark capacitor discharge ignition (CDI) can provide a better result than the standard ignition. Perhaps the best examples are in old 4-stroke engines with conventional points ignition and in all 2-stroke engines.

The faster rise time, hotter sparks and multiple spark discharges can easily fire plugs that are fouled up with carbon caused by oil in the fuel. Again, with an older engine, a multi-spark CDI system can be especially beneficial when the engine is cold and running with a rich fuel mixture.

A CDI also draws less power from the vehicle's 12V battery compared to conventional ignition systems. This can be a real advantage where a vehicle has a low output alternator or generator or in some racing vehicles where no alternator is fitted (eg, in drag racing).

One drawback of CDI systems is the potential of cross-fire between spark plugs due to the rapid rise time of the spark voltage. Cross-fire sounds like "pinging" and can cause severe engine damage if it happens consistently. Therefore, we do not recommend using our High-Energy Multi-Spark CDI system on 6-cylinder and V8 engines unless you can improve the lead dress of the spark plug leads so that each lead is more widely separated from its neighbour.

park CDI

rs

Pt.1: By JOHN CLARKE

Features & Specifications

Main Features

- Suitable for 2-stroke and 4-stroke engines
- Multiple spark output (see Table 1)
- Provides a shorter-duration hotter spark than traditional ignitions
- Operates on reluctor, points, optical, engine management or Hall effect signals
- Usable to 1000 sparks/second (equivalent to 15,000 RPM for a V8)
- Regulated 300V supply for consistent spark energy
- High-frequency operation eliminates audible oscillator noise
- Efficient circuitry for minimum heat generation

Specifications

- Spark energy without multi-sparking: 11mJ measured with Bosch GT40 ignition coil, 15mJ with VW Caravelle T4 ignition coil
- Number of sparks per firing: minimum of 2 (see Table 1)
- Spark separation: 0.5ms for the first two sparks, then 0.66ms, 0.33ms, 0.66ms, etc
- Spark duration: About 200µs per spark
- Multiple spark period: two sparks = 700µs; four sparks = 1.5ms; six sparks = 2.4ms; eight sparks = 3.3ms; 10 sparks = 4.3ms; 12 sparks = 5.2ms; 14 sparks = 6.2ms
- Reluctor circuit sensitivity: 400mV RMS
- Inverter operating frequency: 60kHz
- Operating voltage: down to 9V
- Current drain at 13.8V with multi-sparking: 200mA @ 0Hz, 1A @ 50Hz, 2A @ 150Hz, 3A @ 400Hz, 4A @ 500Hz
- Delay between trigger and firing: 1µs

If you have an older car, there is no reason why this CDI system should not be a satisfactory substitute, particularly if the original module has failed and is expensive to replace.

Our new CDI system can be triggered by conventional ignition points, Hall effect, optical, engine management or reluctor pick-ups. It's capable of operation to very high engine speeds, much higher than even racing engines reach. For example, it can run as high as 30,000 RPM in a 4-cylinder engine. This figure is so high that it's academic but it does indicate that full spark energy is maintained over the entire RPM range of any practical engine.

Multiple spark discharge

Our first Multi-Spark CDI system was published in the September 1997 issue and proved very popular for years after that but it is now obsolete. Now we have completely revised the circuit. So what is "multi-spark"?

Standard transistor-switched and CDI ignition systems produce a single spark each time the mixture in the cylinder is ignited. "Multi-spark" produces several sparks which are fired in quick succession. Our new design produces up to 10 sparks each time a spark plug is to be fired, depending on the engine speed.

If you wish, this feature can be disabled so that the CDI produces just two sparks for each cylinder firing, regardless of engine speed.

The advantage of multi-sparking is that it ensures a more complete burn of the fuel, especially when firing is prone to be difficult in a cold and rich-running engine.

Fig.1(a) shows the schematic diagram of the conventional Kettering ignition system which has been used on cars since 1910 (originally intro-

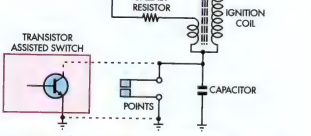


Fig.1(a): the Kettering ignition system uses points or a transistor to interrupt the current through the coil.

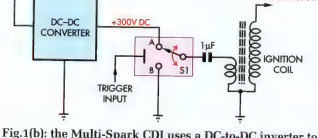


Fig.1(b): the Multi-Spark CDI uses a DC-to-DC inverter to charge a 1µF capacitor when S1 is at A. This capacitor then discharges through the coil when S1 switches to B.

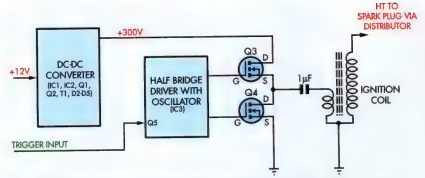


Fig.2: block diagram for the CDI Multi-Spark Ignition. The 300V output from the DC-DC converter is fed to the drain of Mosfet Q3 which is used as a switch to direct current flow through a 1µF capacitor. Mosfet Q4 then shunts the lefthand side of the capacitor to ground to fire the coil (after first switching off Q3). When Q4 is switched off and Q3 is switched back on again, another spark is generated as the 300V DC is re-applied to the capacitor.

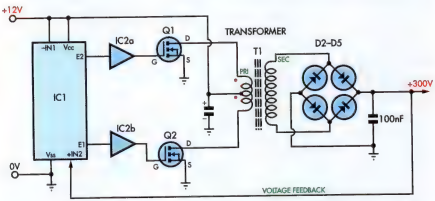


Fig.3: simplified circuit of the DC-DC Converter. Mosfets Q1 & Q2 are driven by a switchmode PWM waveform generated by IC1 via buffers IC2a & IC2b. The Mosfets in turn drive the centre-tapped primary winding of transformer T1 and the output from the secondary is fed to a bridge rectifier (D2-D5) and a 100nF filter capacitor to produce the 300V DC output.

duced on the Cadillac). It comprises an ignition coil which has its primary winding connected to the battery supply and a switch in the negative side.

The switch can be a conventional set of points or a switching transistor, as used in most modern ignition systems. When the switch is closed, current increases in the primary winding and is only limited by the internal resistance of the coil and a ballast resistor (if used). The maximum current is usually up to 5A.

When the switch opens, the resulting collapse of the magnetic field in the coil causes the secondary winding to produce a high voltage to fire the spark plug. As the engine speed rises, the current has less time to build up in the coil primary and so inevitably the spark energy is reduced. Modern transistor-assisted ignition systems get around this problem by using "dwell extension", lower inductance coils or more than one ignition coil, as in direct-fire ignition systems.

Fig.1(b) shows how a typical CDI system works. It has a DC-to-DC inverter with a regulated 300V DC output which charges up a 1µF capacitor. This capacitor charges up via the coil to 300V when S1 is in position A and discharges through the coil when the switch is in position B. Thus each time a spark plug is fired, two sparks are produced – one with positive polarity and one with negative polarity. The CDI can be made to produce more than two sparks for each firing by repeatedly charging and discharging the 1µF capacitor.

Note that older CDI design versions have the lefthand side of the capacitor permanently connected to the DC-DC converter output. This side of the capacitor is switched to ground for firing, usually by an SCR. This arrangement means that the DC-DC converter is effectively shorted to ground and needs to shut down on each firing (otherwise the SCR would continue to conduct).

Fig.2 shows the block diagram for CDI ignition. The DC-DC converter's 300V output connects to the drain of Mosfet Q3 which is used as a switch to direct current flow through the 1µF capacitor. Mosfet Q4 then shunts the left side of the capacitor to ground to fire the coil (Q3 is switched off first). When Q4 is switched off and Q3 switched back on, there is another spark generated as the 300V is reapplied to the capacitor.

DC-DC converter basics

The basic principle of the DC-DC converter is simple. It works by alternately switching the 12V battery supply to each half of a centre-tapped transformer primary winding. The resulting square waveform is then stepped up by the transformer's secondary and then rectified and filtered to provide the 300V DC supply rail.

Fig.3 shows the simplified circuit of the DC-DC Converter. The circuit operates at a switching frequency of about 60kHz and uses a high-frequency ferrite transformer. The centre-tapped primary winding of the transformer is driven by Mosfets Q1 & Q2. Q1 drives the top half of the step-up transformer, while Q2 drives the bottom half. The secondary winding's output is fed to a bridge rectifier and filter capacitor to produce the 300V DC output rail.

The Mosfets are driven by a switchmode PWM (pulse width modulation) waveform generated by IC1. This feeds complementary (ie, out of phase) gate signals to the Mosfets via buffers IC2a & IC2b. Negative feedback is applied to the +IN2 input of IC1 from the 300V DC output via a voltage divider (not shown). This feedback circuit acts to reduce the width of the pulses applied to the Mosfets if the DC voltage rises above 300V.

Conversely, the pulse width from the driver circuit increases if the output voltage falls below 300V. Since the Mosfets are switched in anti-phase, when one half of the winding is conducting, the other is off.

The DC-DC circuit also incorporates a low voltage cut-out to protect the battery from over-discharge. It monitors the battery voltage at -IN1 and if it drops below 9V, the DC-DC converter switches off.

Circuit details

Refer now to Fig.4 for the full circuit

siliconchip.com.au

Parts List

1 PCB, code 05112141, 110.5 x 85mm
1 diecast metal case, 119 x 94 x 57mm (Jaycar HB-5064 or equivalent)
1 ETD29 transformer (T1) consisting of 1 x 13-pin former (element14 Cat. 1422746), 2 x N87 cores (element14 Cat. 1781873) & 2 x clips (element14 Cat. 178507)
1 S14K 275VAC Metal Oxide Varistor (MOV1) (Jaycar RN3400, Altronics R4408
2 IP68 cable glands, 4-8mm cable diameter
4 M3 x 9mm tapped spacers
4 TO-220 silicone insulation washers
4 insulating bushes
1 100kΩ top-adjust multi-turn trimpot (VR1)
4 M3 x 9mm tapped Nylon spacers
5 M3 x 10mm screws
4 M3 x 6mm screws
4 M3 x 6mm countersink-head screws
5 M3 nuts
2 3mm star washers
2 solder lugs
1 20m length of 0.25mm-diameter enamelled copper wire (for T1 secondary)
1 1200mm length of 1.0mm-diameter enamelled copper wire (for T1 primary)
1 2m length of red automotive wire
1 2m length of black automotive wire
1 2m length of green automotive wire
1 2m length of white automotive wire

Semiconductors
1 TL494CD SOIC switchmode PWM control circuit (IC1)*
1 TC4427COA SOIC high-speed Mosfet driver (IC2)*
1 L6571AD SOIC high-voltage half-bridge driver with oscillator (IC3)*
2 STP60NF06 60V 60A N-channel Mosfets (Q1,Q2)*
2 FDP10N60NZ 10A 600V N-channel Mosfets (Q3,Q4)*
2 BC337 NPN transistors (Q5,Q6)
1 16V 1W zener diode (ZD1)
1 75V 1W zener diode (ZD2)
1 1N4004 1A 400V diode (D1)
5 UF4007 fast rectifier diodes (D2-D6)
3 1N4148 switching diodes (D7-D9)
* available from au.element14.com

Capacitors
1 4700µF 16V PC low-ESR electrolytic
3 100µF 16V PC low-ESR electrolytic
1 10µF 16V PC electrolytic
2 1µF 50V monolithic multilayer ceramic (MMC)
1 1µF X2 class 275VAC MKP metallised polypropylene (Vishay BFC233922105)
2 100nF X2 class 275VAC MKP metallised polypropylene
3 100nF 63/100V MKT
1 4.7nF 63/100V MKT
1 1nF 63/100V MKT
1 C1 (470nF for 8-cylinder, 150nF for 6-cylinder, 120nF for 4-cylinder), 63/100V MKT

Resistors (0.25W, 1%)

3 1MΩ	1 13kΩ
2 680kΩ	7 10kΩ
2 270kΩ	1 8.2kΩ
2 180kΩ	2 4.7kΩ
1 56kΩ	1 2.2kΩ
2 47kΩ	2 22Ω
1 33kΩ	3 10Ω
2 33kΩ 1W	

Points version
1 100Ω 5W resistor (R1)

Reluctor version
1 BC337 NPN transistor (Q7)
1 5.1V 1W zener diode (ZD3)
1 2.2nF MKT polyester capacitor
1 470pF ceramic capacitor
1 100kΩ top adjust multi-turn trimpot (VR2)
1 47kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor
1 10kΩ 0.25W 1% resistor (R4)
1 1kΩ 0.25W 1% resistor (R3)
2 150Ω 0.25W 1% resistors

Hall Effect/Lumenition Module
1 5.1V 1W zener diode (ZD3)
1 150Ω 0.25W 1% resistor
1 1kΩ 0.25W 1% resistor (R3)
1 100Ω 0.25W 1% resistor (R2)

Optical Pick-up
1 optical pick-up (Piranha or Crane)
1 5.1V 1W zener diode (ZD3)
1 22kΩ 0.25W 1% resistor (R3 or R6)
2 150Ω 0.25W 1% resistors
1 120Ω 0.25W 1% resistor (R4 or R5)

Miscellaneous
Heatshrink tubing, angle brackets for mounting, automotive connectors, self-tapping screws, etc

of the Multi-Spark CDI system. Its DC-DC converter is based on a Texas Instruments TL494 switchmode driver (IC1).

This device has been available since the early 1980s and is still used today in many switchmode power supplies. The IC contains all the necessary circuitry to generate complementary square-wave outputs at pins 9 & 10 and these drive the gates of the Mosfets via Mosfet drivers. The IC also contains control circuitry to provide output voltage regulation and low voltage cut-out.

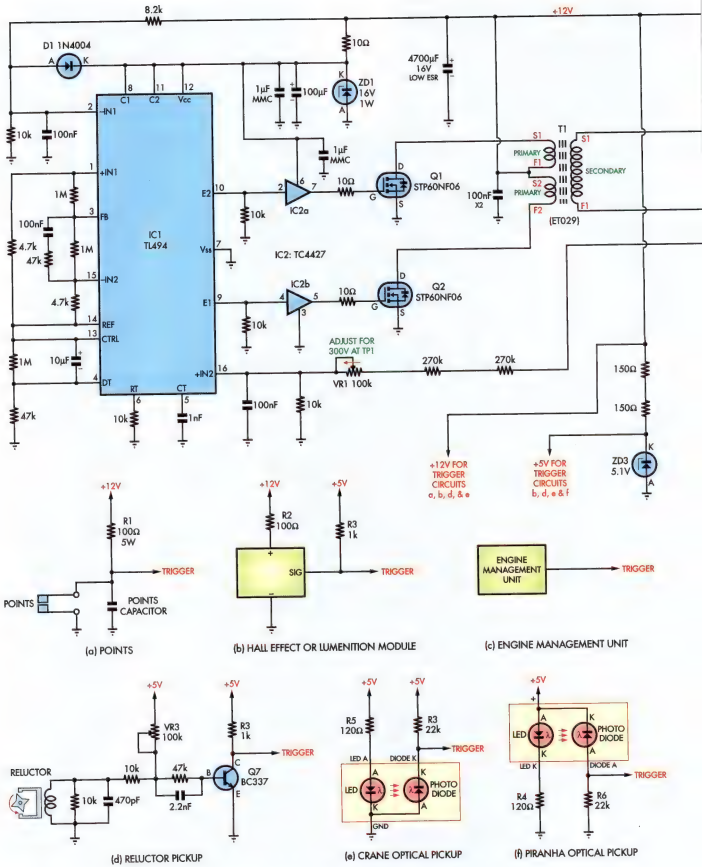
Fig.5 shows the internal circuitry of the TL494. It's a fixed-frequency PWM controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single-ended operation.

The PWM comparator generates the variable width output pulses by comparing the sawtooth oscillator waveform against the combined outputs of the two error amplifiers. The error amplifier with the highest output voltage sets the pulse width.

The control (CTRL) output at pin 13 of IC1 is used to set either single-ended output or push-pull operation. In our design, push-pull (ie, anti-phase) outputs are selected and these are produced at the transistor emitters at pins 9 & 10 (E1 & E2). These internal transistors have their collectors tied to the positive supply rail.

Dead-time comparator

The internal dead-time comparator ensures that there is a brief delay before one output goes high after the other has gone low. This means that the outputs at pins 9 & 10 are both low for a short time at the transition points. This dead-time period is essential



MULTISPARK CAPACITOR DISCHARGE IGNITION

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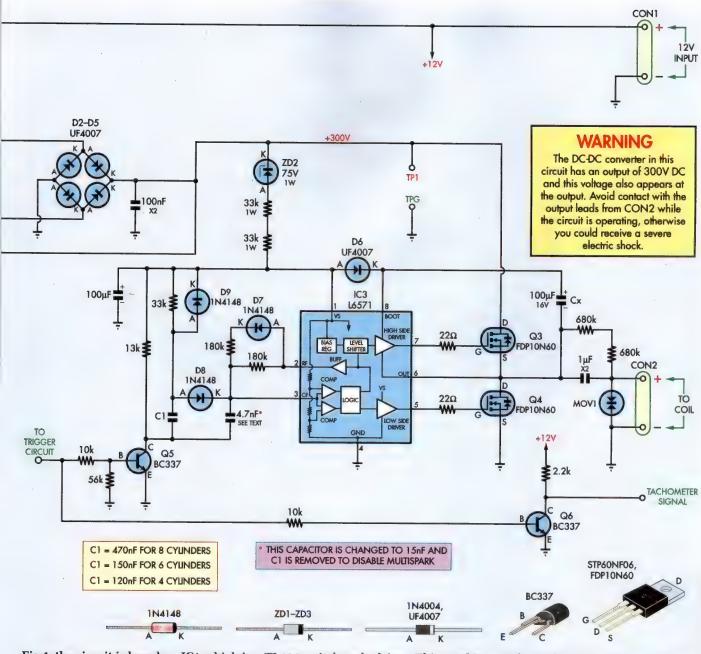

Fig.4: the circuit is based on IC1 which is a TL494 switchmode driver. This combines with Mosfets Q1 & Q2, transformer T1 and bridge rectifier D2-D5 to form the DC-DC converter. IC3, an L6571AD high-voltage half-bridge driver and oscillator, is used to alternately switch Mosfets Q3 & Q4 to charge and discharge the 1µF capacitor via the ignition coil. The circuit caters for six different input triggers: (a) points; (b) Hall effect/Lumenition triggering; (c) engine management module triggering; (d) reluctor pickup; (e) Crane optical pickup; and (f) Piranha optical pickup.

because without it, the Mosfet driving one half of the transformer primary would still be switching off while the Mosfet driving the other half was switching on. As a result, the Mosfets would be destroyed as they would effectively create a short circuit across the 12V supply.

One of the error amplifiers in IC1 is used to provide the under-voltage cut-out feature. This is done by connecting its pin 2 inverting input to the +12V rail via a voltage divider consisting of 10kΩ and 8.2kΩ resistors. The non-inverting input at pin 1 connects to IC1's internal 5V reference at pin 14 via a 4.7kΩ resistor.

When the voltage at pin 2 drops below 5V (ie, when the battery voltage drops below 9V), the output of the error amplifier goes high and the PWM outputs at pins 9 & 10 go low, shutting the circuit down. Note the 1MΩ resistor between the non-inverting input at pin 1 and the error amplifier output a pin 3. This provides a small amount of hysteresis so that the output of the error amplifier does not oscillate at the 9V threshold.

The second error amplifier in the TL494 is used to control the output voltage of the DC-DC converter. The feedback voltage is derived from the positive side of the bridge rectifier and fed via a voltage divider consisting of two 270kΩ resistors and trimpot VR1 in series, plus a 10kΩ resistor to ground. The resulting voltage is then fed to pin 16 of IC1 and compared to

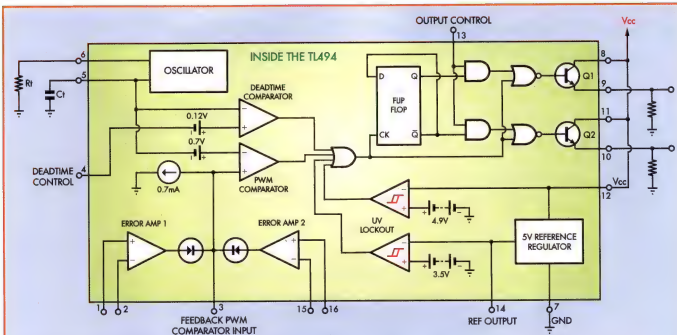

Fig.5: the internal circuit of the TL494 Switchmode Pulse Width Modulation (PWM) Controller. It is a fixed-frequency PWM controller containing a sawtooth oscillator, two error amplifiers and a PWM comparator. It also includes a dead-time control comparator, a 5V reference and output control options for push-pull or single-ended operation.

the internal 5V reference which is applied to pin 15 via a 4.7kΩ resistor.

Normally, the attenuated feedback voltage should be close to 5V. Should this voltage rise (due to an increase in the output voltage), the output of the error amplifier also rises and this reduces the output pulse width. Conversely, if the output falls, the error amplifier's output also falls and the pulse width increases.

The gain of the error amplifier at low frequencies is set by the 1MΩ feedback resistor between pins 3 & 15 and by the 4.7kΩ resistor to pin 14 (V_{REF}). These set the gain to about 213. At higher frequencies, the gain is set to about 9.5 by virtue of the 47kΩ resistor and 100nF capacitor in series across the 1MΩ resistor. This reduction in gain at the higher frequencies prevents the amplifier from responding to hash on the supply rails.

The 10kΩ resistor and 1nF capacitor at pins 6 & 5 respectively set the internal oscillator to about 120kHz. This is divided by two using an internal flipflop to give the resulting complementary (anti-phase) output signals at pins 9 & 10. The resulting switching rate of the Mosfets is 60kHz.

Pin 4 of IC1 is the dead-time control input. When this input is at the same level as V_{REF}, the output transistors are off. As pin 4 drops to 0V, the dead-time decreases to a minimum. At switch on, the 10μF capacitor between V_{REF} (pin 14) and pin 4 is discharged and this initially holds pin 4 at 5V. This prevents the output transistors in IC1 from switching on.

The 10μF capacitor then charges via the 47kΩ resistor (between pin 4 & ground) and so the duty cycle of the output transistors slowly increases until full control is gained by the error amplifier. This effectively provides a soft start for the converter. The 1MΩ resistor between pins 4 & 13 has been included to provide more dead-time. It prevents the 10μF capacitor from fully charging to 5V and this increases the minimum dead-time period.

Complementary outputs

As stated, the complementary PWM outputs at pins 9 & 10 of IC1 come from internal emitter follower transistors. These each drive external 10kΩ pull-down resistors and Mosfet drivers IC2a & IC2b which can deliver up to 1.5A charge/discharge current into the Mosfet gates, for fast and clean switching.

Note the 100nF X2 capacitor and the 4700μF low-ESR capacitor between the centre tap of the transformer primary and ground. These are there to cancel out the inductance of the leads which carry current to the transformer. They effectively provide the peak current required from the transformer as it switches.

Transformer T1 is a relatively small ferrite-cored unit designed to be driven at high frequencies. This is a similar arrangement to that used in the Ultrasonic Cleaner (August 2010) and in the Ultrasonic Anti-Fouling Unit For Boats (September & November 2010). Its primary and secondary windings are wound using enamelled copper wire, with the number of turns set to provide the required output voltage.

In operation, the power Mosfets alternately switch each side of the transformer primary to ground, so that the transformer is driven in push-pull mode. When Q1 is on, the 12V supply is across the top half of the primary winding, and when Q2 is on the supply is across the bottom half. This alternating voltage is stepped up by the secondary and applied to a full-wave bridge rectifier comprising UF4007 ultra-fast recovery diodes D2-D5.

These ultra-fast diodes are necessary because of the high switching frequency of 60kHz. A 100nF X2 capacitor filters the 300V DC output and this is fed to the drain of Mosfet Q3 and also to IC3, an L6571 half-bridge Mosfet driver and oscillator, via 75V zener diode ZD2 and two series 33kΩ 1W resistors.

IC3's supply at pin 1 is set to 15V by

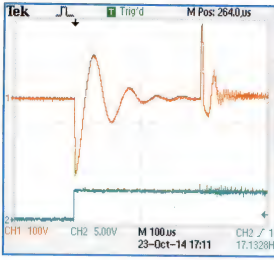

Fig.6: channel 1 (orange trace) of this scope shot shows the primary coil voltage at the coil+ output with multi-sparking disabled, while channel 2 (cyan) shows the input trigger signal. Note the -296V first spark voltage at the firing point and the +292V voltage excursion for the second spark 500µs later.

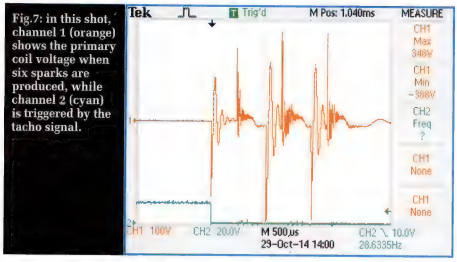

Fig.7: in this shot, channel 1 (orange) shows the primary coil voltage when six sparks are produced, while channel 2 (cyan) is triggered by the tacho signal.

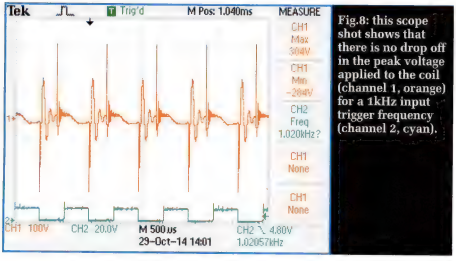

Fig.8: this scope shot shows that there is no drop off in the peak voltage applied to the coil (channel 1, orange) for a 1kHz input trigger frequency (channel 2, cyan).

an internal zener diode. ZD2 is used to drop the 300V supply before feeding it to the 33kΩ resistors, so that each dissipates no more than 334mW.

Driving Q3

In order for Mosfet Q3 to fully turn on, its gate must be raised above its drain by several volts and this is the job of IC3, the L6571 half-bridge driver. It produces the necessary higher gate voltage using diode D6 and a 100µF capacitor (Cx) between Q3's source and pin 8.

Initially, IC3 starts with a 15V supply derived from the 300V rail, as

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Table 1: RPM vs Spark Number & Duration

RPM	Distributor Trigger Frequency (Hz)	No. of Sparks	Multiple Spark Duration (Crankshaft Degrees)
4-Cylinder 4-Stroke Engines			
600	20	6	8
900	30	6	13
1200	40	6	16
1500	50	6	20
2250	75	4	19
3000	100	4	25
4500	150	4	37
9000	300	2	21
15,000	500	2	36
6-Cylinder 4-Stroke Engines			
400	20	8	8
600	30	8	12
800	40	6	11
1000	50	6	14
1500	75	6	21
2000	100	4	16
3000	150	4	24
6000	300	2	14
10,000	500	2	22
8-Cylinder 4-Stroke Engines			
300	20	14	11
450	30	12	13
600	40	10	15
750	50	10	18
1125	75	8	21
1500	100	8	20
2250	150	6	29
4500	300	4	32
7500	500	2	15

mentioned above. Q4 is the first to be switched on and it pulls one side of capacitor Cx low. Cx then charges to the +15V supply via D6 and Q4.

When Q4 turns off and Q3 turns on, Q3 pulls pin 6 of IC3 up to the 300V rail and so pin 8 is jacked up above +300V by the 15V across the capacitor. The voltage across Cx is then maintained until next recharged via D6 & Q4 (note that pins 6, 7 & 8 of IC3 are floating outputs which can be shifted up to 600V above the pin 4 ground).

Cx needs to be relatively large at 100µF since it can be called on to keep its charge for up to 100ms during slow cranking of the motor. The totem-pole output of Mosfets Q3 & Q4 drives the ignition coil primary via the 1µF X2 capacitor.

The 22Ω gate resistors slow the turn-on and turn-off times for Q3 & Q4, to limit transients when switching the 1µF capacitor.

Multi-sparking

Multi-sparking is possible because IC3 incorporates a self-oscillating section involving two comparators, as shown by its internal block diagram on Fig.4. The series resistor string sets the inputs of the two comparators at 2/3rds and 1/3rd of the 15V supply, while the external 4.7nF capacitor and 180kΩ resistor configure the two comparators as an astable multivibrator. It operates in a very similar way to a 555 timer IC connected in astable mode.

In our circuit, we have added diode D7 and another 180kΩ resistor in series. This ensures that the discharge period for the 4.7nF capacitor via one of the 180kΩ resistors is much longer than charging period via both 180kΩ resistors and D7 when the latter is forward biased by pin 2.

Note that the 4.7nF capacitor is only tied to ground when transistor Q5 is switched on via the trigger circuit. Capacitor C1 is also connected to the collector of Q5. Initially, when Q5 is off, C1 is discharged and held at the pin 1 supply voltage (+15V) via the 13kΩ resistor at Q5's collector and the 33kΩ resistor at D8's anode. This last resistor pulls pin 3 of IC3 well above the upper threshold (2/3rds the pin 1 supply) via D8. As a result, pin 2 goes low but the 4.7nF capacitor cannot be discharged and so IC3 doesn't oscillate. This in turn means that Mosfet Q4 is off and Q3 is on.

When Q5 switches on due to an input trigger signal, D8's anode is pulled low via C1. Thus, the 33kΩ resistor is temporarily out of the oscillator circuit and so the 4.7nF capacitor is charged and discharged via the components at pin 2 as previously discussed. Q4 and Q5 now switch on and off alternately and so the coil is fired repetitively.

C1 now again charges via the 33kΩ resistor and when its voltage reaches the upper threshold of pin 3's input, the oscillator stops as described before.

Note that at high RPM, Q5 is on for less time than it takes C1 to recharge via the 33kΩ resistor and switch off IC3's oscillation. The instant this transistor switches off, IC3 stops oscillating since C1 is immediately pulled high. This is a fail-safe condition to prevent sparks designated for one cylinder from accidentally firing the next cylinder in sequence.

The trigger circuit also drives transistor Q6 to provide a low voltage (+12V) tachometer output. This is necessary, since a tachometer connected to the coil would otherwise give false readings.

Disabling multi-spark mode

If you wish, the multi-spark feature can be easily disabled by removing C1 and replacing the 4.7nF capacitor with a 15nF capacitor instead.

Beware Of Similar ICs

Note that there are similar half bridge self-oscillating Mosfet drivers to the L6571. This includes the IR2155 that we used in our previous Multi-Spark CDI design in September 1997. The IR2155 is now an obsolete part.

There are also what may appear to be similar drivers. These include the IR2153, the IR25603 and the IRS2153. Don't use these in this circuit – they won't work properly!

This modification now causes IC3 to produce a single 0.5ms pulse to switch on Q4. This fires the coil in one direction when Q4 switches on and in the other direction when Q3 switches on.

A Metal Oxide Varistor (MOV1) is connected across the coil to quench the high-voltage transient which will occur if the coil is left open-circuit on the secondary. Leaving the coil output open-circuit can cause it to break down internally and this quickly leads to failure.

Two 680kΩ resistors are connected in series across the 1µF X2 output capacitor to discharge it should the coil become disconnected from the circuit. This is a safety measure since a 1µF capacitor charged to 300V can produce a very nasty shock.

Trigger inputs

Because this Multi-Spark CDI is intended for use with a wide range of engines, we have made it compatible with six different trigger sources. These are all shown on the main circuit of Fig.4.

The points input circuit (a) simply comprises a 100Ω 5W resistor connected to the 12V supply. This resistor provides a wetting current for the points to ensure their contacts remain clean. The points connect to the trigger input associated with Q5.

The Hall effect or Lumenition (optical trigger) module input (b) uses a 100Ω supply resistor (R2) to the +12V rail. This resistor limits the current into the internal clamping diode of the Hall effect or Lumenition unit. The 1kΩ resistor (R3) pulls the output voltage up to +5V when the internal open-collector transistor is off. Conversely, the output voltage falls to near 0V when the internal transistor turns on.

The engine management input (c) is very straightforward; the 5V signal output from the vehicle's engine management unit simply connects to the trigger input.

The High-Energy Multi-Spark CDI is housed in a rugged diecast metal case which provides good heatsinking for the four Mosfets. It's mounted in a splash-proof location in the engine bay, preferably where air can flow over it and well away from the hot exhaust manifold and exhaust pipes.

Reluctor triggering

The reluctor input circuit (d) is the most complex. In operation, the reluctor coil produces an AC signal which switches transistor Q7 on and off. This works as follows: with no reluctor voltage, transistor Q7 is biased on via trimpot VR2 and the 47kΩ resistor to its base. The actual voltage applied to Q7's base depends on the 10kΩ resistor connected to the top of the reluctor coil and on the internal resistance of the reluctor.

Trimpot VR2 is included to cater for a wide range of reluctor resistance values. In practice, VR2 is adjusted so that Q7 is just switched on when there is no signal from the reluctor. When the signal goes positive, Q7 remains switched on. When the signal goes negative, Q7 is switched off.

Resistor R4 provides loading for the reluctor, while the 470pF capacitor shunts any high-frequency signals. The 2.2nF capacitor speeds up Q7's switch-on and switch-off times.

Optical triggering

Two optical (photoelectric) triggering versions are catered for, one for a Crane pick-up (e) and one for a Piranha pick-up (f). The Crane trigger has a common ground connection while the Piranha has a common positive. For the Crane trigger, resistor R5 feeds current to the internal LED from the +5V supply, while R3 functions as a pull-up resistor for the photodiode.

Similarly, for the Piranha trigger, R4 is the current resistor for the LED, while R6 functions as pull-down for the internal photodiode.

That's all for this month. Next month, we'll describe the PCB assembly and the test and installation procedures. SC

Warning – High Voltage!

This circuit produces an output voltage of up to 300V DC to drive the coil primary and is capable of delivering a severe (or even fatal) electric shock. DO NOT TOUCH any part of the circuit or the output leads to the coil from CON2 while power is applied.

To ensure safety, the PCB assembly must be housed in the recommended diecast case. This case also provides the necessary heatsink for the four Mosfet – see Pt.2 next month.

Just in time for Christmas...

Tecsun PL-880 PLL Synthesised DSP Receiver

by Ross Tester

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It's been a while since Tecsun Radios Australia added a new model to their range but the new PL880 looks like the wait has been worth it!

It's described as a "high sensitivity world band radio" but that is almost damning it with faint praise – it's so much more than that and would suit every user from the occasional eavesdropper to the dedicated shortwave listener.

Because it offers digital signal processing (DSP) on SSB as well as the more usual FM, and because it offers 10Hz steps on USB/LSB it would also be ideal for resolving HF amateur radio transmissions, which almost invariably these days are SSB.

Digital signal processing offers cogent performance advantages, particularly in the reception of weak signals.

It's definitely not a pocket-sized receiver – at 190 x 113 x 32mm, the PL880 is significantly larger than most of the other Tecsun models we've seen. And at about 600g including battery, it's not a lightweight either! But they've obviously used the extra space to offer features and performance which far exceed those of the smaller cousins.

First, the bands covered are somewhat expanded: FM starts at 64MHz, up to the usual 108MHz, so you get quite a lot of the low-VHF band as well as the usual 88-108MHz FM broadcast band. You'd be surprised what there is to listen to down there – take it to the football and listen in to the referees' radios, for example.

Similarly, the AM broadcast band is a little wider than normal at 520-1710kHz and the "shortwave" bands starts right at 1711kHz and go all the way up to 29999kHz (29.999MHz) in 1kHz steps.

A long-wire shortwave antenna is supplied which plugs into a socket on the side of the radio – this socket can also be used to connect a better (ie, resonant) antenna.

Before we get into the technicalities of this radio, we also note a significant departure from previous power.

Most small radios (previous Tecsuns included) operate from "AA" cells. Usually there are three of them (for either 4.5V or 3.6V, depending on whether they are alkalines or rechargeable Nicads). This one, though, has a single "18650" 3.7V, 2Ah Lithium-ion cells appeared in SILICON CHIP, June 2013.

It's supplied with a 5V (and Australian approved!) mains plugpack (no getting fried by dodgy cheapos here . . .).

Being 5V, it will also operate from a USB socket, whether that's on a computer or any other device. The 5V supply also charges the Li-ion cell whenever plugged in. Incidentally, the Li-ion cell is removable, just the same as with AA cells, so it can be replaced when it will no longer accept charge. That's likely to be years away, depending on use.

The audio is significantly better than you'd get from a typical small radio, with a 450mW class AB amplifier and full-range speaker built in. There's also a bass/treble switch and a 3.5mm stereo headphone socket is also built in (with ear buds supplied). A line output socket is provided for a recorder, external amplifier, telephone system etc.

Of particular interest to shortwave listeners is the user-selectable IF bandwidth: on AM you can choose 9.0 or 5.0kHz; SSB gives you the choice of 4.0, 3.0, 2.3, 1.2 and 0.5kHz. HF sensitivity is typically less than 1μV.

Tuning

You can manually tune by selecting the band required and turning the largest tuning knob, or you can scan for stations or you can use the keypad to directly enter the station frequency. Pressing the VF/VM key will, alternately, reveal the station (frequency) currently tuned or the station (from memory) currently selected.

Memories

Speaking of the memory, there are 3050 available (yes, 3050!) arranged in 25 pages. The first page can accommodate 650 station memories; the other 24 pages 100 each. So if you have trouble remembering a station, you might have just as much trouble remembering where you stored that station. A notebook or computer database might help! You can store the stations manually, semi-automatically or what they call ATS, (Auto Tuning Storage). We won't even try to explain the processes involved: you can read that when you buy your Tecsun PL-880.

Clock/Alarm

The radio has a clock, sleep timer, snooze and alarm timer – you can set the alarm to sound anywhere from 1–90 minutes (if you haven't woken after 90 minutes, you probably should replace your hearing aid batteries). The snooze timer is fixed at five minutes. There's also a backlight which can auto turn-off if you wish.

Hidden features

While the majority of users will gain all the information they need to drive the Tecsun PL880 from the user manual supplied, there are several "hidden" features that aren't detailed and the advanced user might find useful. Tecsun Radios Australia have detailed these on a separate PDF sheet which they will supply on request. These features include:

Activating synchronous detection (LSB and USB)

Changing the FM de-emphasis (you can change from factory set 50μs to 75μs)

Changing the line output level

Adding a 'seconds' display to the time

Adjust the low-voltage shutdown point

Displaying the software version and build date

Displaying remaining battery life

In use

What else can we say but WOW? It's a good looking radio, it's a great sounding radio and it has every feature you could possibly want (and then some). In fact, in the time we had to play with it, we reckon we just scratched the surface of what it can do. And even then, it was impressive, to say the least.

At $239.00 (inc GST) it's not a cheap radio. If you want a cheaper model, Tecsun Radios Australia (part of the Av-Comm group) have them from under $30. But if you want a radio that offers exceptional performance and a great range of "creature comforts", you can't go past the Tecsun PL-880. SC

***Tecsun Radios Australia, 24/9 Powells Rd, Brookvale NSW 2100. Tel (02) 9939 4377; website www.tecsunradios.com.au**

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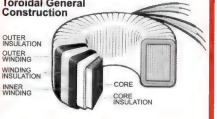

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

MEN hazard warning alarm

The recent article in the August 2014 issue of SILICON CHIP highlighted some possible failure modes in the MEN system which could lead to electrocution.

As noted, if there is a failure in the main Neutral connection to the dwelling, currents can flow from devices such as hot water tank heater elements to the Earth connection. Because the Earth stake itself is not a perfectly low impedance connection, this raises the dwelling's Earth voltage. Then a person can possibly receive a fatal electric shock from anything that might be earthed, such as taps connected to water pipes or even the metal body of earthed appliances.

If the impedance of the Earth connection is high, due to the soil composition around the stake or corrosion in the connection, then some voltage (up to the full mains voltage) can be present on the dwelling's Earth connections including metal water pipes and taps.

The alarm described here has the following properties:

(1) It uses an independent Earth as a reference potential. This is an additional standard earthing stake which is independent of any other Earth connection.

(2) The device is battery-powered and still functions in the event of mains power failure in the dwelling.

(3) The standby current in the device is zero, so that the battery's shelf life is attained.

(4) The device sounds an audible and visual alarm if there is AC voltage, above a certain threshold, detected on any structure or Earth or Neutral connection being monitored.

(5) The device has a memory and a reset button and records the source of the alarm activation.

(6) The sensing currents are in the 50μA range and the addition of the device poses no risk of electrocution.

(7) The sensing inputs to the device include bandpass filters to reject voltage transients at frequencies well below or above the mains frequency (50Hz). Thus, there is no response to static discharges, undulating DC levels or radio frequencies.

(8) The device inputs are constructed from components which are not damaged or degraded by the application of full mains voltage, if that event ever occurs.

(9) Due to the low sensing currents (high impedance input of the alarm circuitry), the reference earth can be of poor quality and be of a high resistance in dry soil and the alarm still works normally. An excellent low-resistance reference earth is not required for proper operation.

The circuit monitors three voltages with respect to the independent earth stake: GPO (power point) Earths, water pipes and the Neutral at the GPOs. So there are three inputs, each fed via a 4.7MΩ or 10MΩ high-voltage resistor and a 68nF X2 capacitor to a half-wave rectifier consisting of diodes D1 & D2 (etc) and a 220nF capacitor. The resulting voltage fed to the gates of the BS270 Mosfets is limited to 10V by the associated zener diode. The input signal to the Mosfets is also band-pass limited by the 4.7MΩ/10MΩ resistor, the 68nF capacitor, the 1nF capacitor and the 220nF capacitor. This gives a response of between about 0.2Hz and 100Hz. The unit won't respond to slowly undulating DC levels (ie, below 0.2Hz).

Once the gate threshold of the BS270 is reached, the BS270 causes the associated BC327 transistor to conduct. Positive feedback to the gate of the Mosfet causes the circuit to latch on. Only then does the circuit draw current from the 12V battery pack and sound the alarm. As the condition is latched, then the input which received the peak voltage over the threshold keeps its associated LED lit as well, so it is easy to see which channel triggered the alarm.

The "earth lift" voltage threshold is set at 9V peak, while detection of "Neutral lift" is set at 20V peak.

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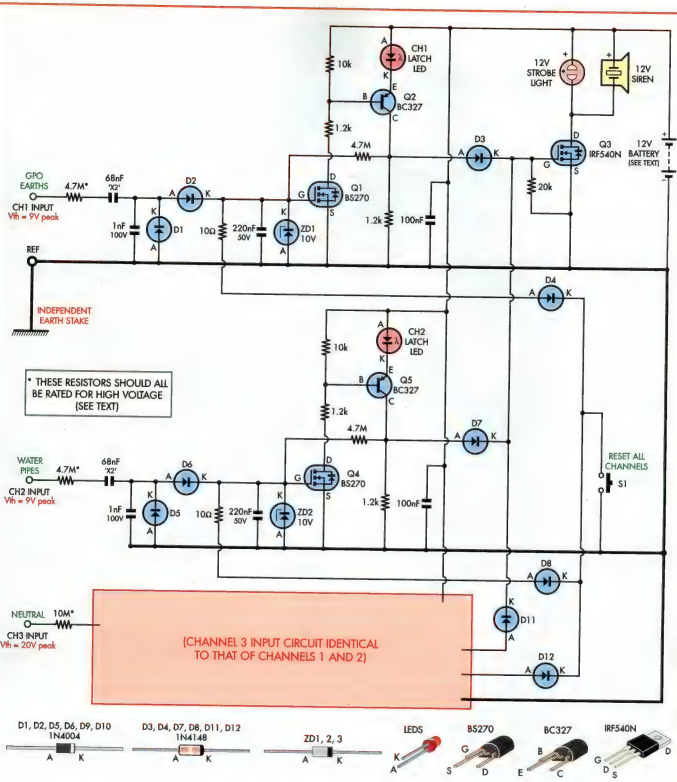

With some appliances drawing high currents and the resistive loss in the Neutral wiring, it is not uncommon for the Neutral to be peaking a few volts above ground.

The battery consists of eight AA cells in a black Nylon battery holder. However, these holders can bend and crack due to the spring force and hardening of the plastic, so it is wise to tightly tape the batteries in the holder to prevent any loss of function.

Note 1: this unit would need to be installed by a licensed electrician. Similarly, any triggering of the alarm would call for inspection by a licensed electrician or the electrical supply company if it's a street supply fault.

Note 2: TV focus high-voltage resistors (10kV DC, 7kV RMS) are used at the inputs and these are available from WES Components in Australia: www.wes.com.au

Dr Hugo Holden,
Maroochydore, Qld. ($100)

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(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board see Nov 2012/May 2013)			
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PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)	
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)	
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14) Remote Mains Timer (Nov14)	
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13)	
PIC16LF88-I/SO	LED Ladybird (Apr13)	
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semitest (Feb-May12)	
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)	
PIC18F45K80	USB Power Monitor (Dec12)	
PIC18F4550-I/P	GPS Car Computer (Jul11), GPS Boat Computer (Oct10)	
PIC18F14K50	USB MIDIMate (Oct11)	

PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)	
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PIC18F1320-I/SO	Intelligent Dimmer (Apr09)	
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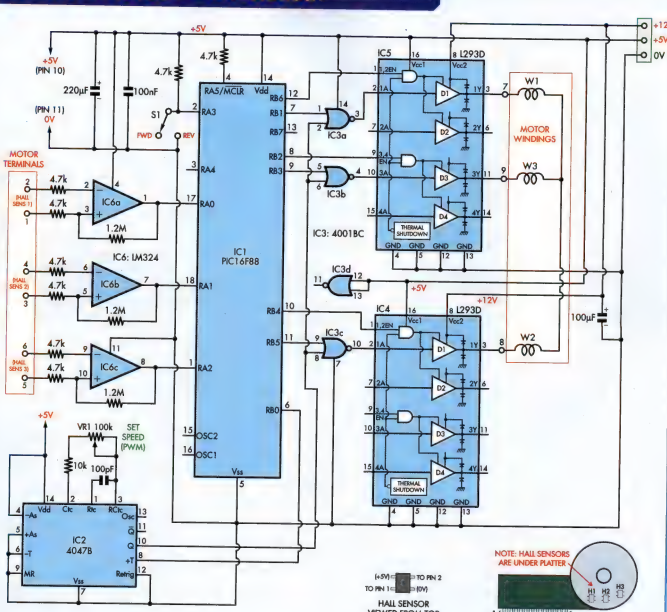


CLOCKWISE ROTATION									RESULT		
RA0	RA1	RA2	RB6	RB1	RB2	RB3	RB4	RB5	W1/ IC5.1A	W2/ IC4.1A	W3/ IC5.3A
1	0	0	1	1	0	X	1	0	0	PWM	X
1	1	0	1	1	1	0	0	X	0	X	PWM
0	1	0	0	X	1	0	1	1	X	0	PWM
0	1	1	1	0	X	0	1	1	PWM	0	X
0	0	1	1	0	1	1	0	X	PWM	X	0
1	0	1	0	X	1	1	1	0	X	PWM	0

X = HIGH IMPEDANCE FOR W1, W2, W3, DON'T CARE FOR IC5.1A, IC5.3A, IC4.1A

ANTICLOCKWISE ROTATION									RESULT		
RA0	RA1	RA2	RB6	RB1	RB2	RB3	RB4	RB5	W1/ IC5.1A	W2/ IC4.1A	W3/ IC5.3A
1	0	0	1	0	0	X	1	1	PWM	0	X
1	1	0	1	0	1	1	0	X	PWM	X	0
0	1	0	0	X	1	1	1	0	X	PWM	0
0	1	1	1	1	0	X	1	0	0	PWM	X
0	0	1	1	1	1	0	0	X	0	X	PWM
1	0	1	0	X	1	0	1	1	X	0	PWM

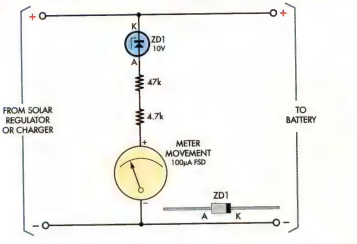
X = HIGH IMPEDANCE FOR W1, W2, W3, DON'T CARE FOR IC5.1A, IC5.3A, IC4.1A

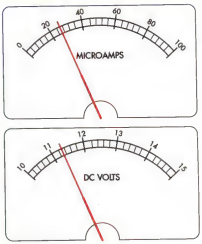
Forward/reverse drive for DVD brushless DC motors

Most readers will have discarded DVD players and computer CD ROMs in their junk boxes. If you strip them down you will find that the spindle is usually driven by a small brushless motor (this motor is depicted on the above circuit). This drive circuit enables you to run them in both directions and vary the speed using a potentiometer from a few revs to over 8000 RPM.

To rotate the motor you have to switch each winding in the sequence shown in the accompanying tables

continued on page 52





Suppressed zero meter using a zener diode

If you are monitoring a 12V lead-acid battery, only a small portion of the scale on an analog meter will be used. For example, on a meter with a full-scale deflection (FSD) voltage of 15V, only a small portion of the upper half of the scale will ever be used. However, by connecting a zener diode in series with the meter movement, we can "suppress" the lower portion of the meter and expand the scale (over a small voltage range) to provide increased resolution in the measurement.

In the case of the accompanying circuit, a 10V zener diode is connected in series with the meter and this sets the minimum reading on the scale. Resistors R1 and R2 set the full-scale deflection at 15V DC. In effect, because the minimum reading of the meter is 10V (set by the zener diode), the meter's actual FSD is 5V, giving a maximum reading of 15V.

If the meter's sensitivity is 100µA for FSD, then the values for R1 and R2 can be calculated using Ohm's Law; ie, R = V ÷ I.

With V = 5V and I = 100µA, R = 5 ÷ 0.0001 = 50kΩ

This can be made up with R1 being 47kΩ and R2 as 3kΩ. In practice, R2 should be selected with aid of a digital multimeter so the analog meter's full scale deflection voltage can be precisely set at 15V.

The same process can be used with a 1mA meter movement and it can be extended if you want to monitor 24V batteries. In this case, you could use two 10V zener diodes in series with the meter movement and select R1 & R2 accordingly to provide an FSD of 30V. This will allow for a fully-charged battery voltage of 28.8V DC. Equally, the same principle can be applied if you want to measure any battery voltage such as 32V, 48V etc.

Finally, it is desirable to use 10V zener diodes in this application. While 5V zener diodes have a very low temperature coefficient, their "knee" (ie, turn-on) voltage is quite gradual. 10V zener diodes have a much sharper knee but have a lower temperature coefficient than 20V types.

David Francis,
Kilburn, SA. ($40)

DVD motor drive continued . . .

under W1, W2, & W3. You can see how this sequence is derived in a complete description on the internet by searching for "BLDC motors with Hall sensors".

In the table, 0 means that the winding is connected to 0V, X means it is connected to a very high impedance and PWM means that it is connected to a square wave with an amplitude varying between 0V and +12V. The mark-space ratio of this waveform determines the average voltage applied to the motor which in turn determines its rotational speed.

Two L293D 4-channel half H-bridge driver ICs are used drive the motor. The output of these ICs follows the input if the enable pin is high and is at a high impedance when the input is low. The reason for having two L293D ICs is that a common enable pin is used for each pair of drivers in the package which doesn't suit the required rotation logic.

To obtain the PWM signal, microcontroller IC1 (PIC16F88) produces a 22.8kHz square wave at its pin 6 output. This triggers a 4047 monostable whose output pulse varies between 3.7µs to 41µs, depending on the setting of the 100kΩ potentiometer. In other words, the mark-space ratio changes with the setting of the 100kΩ potentiometer (VR1).

The 4001B NOR gates determine if the inputs to the motor drivers are connected to the PWM signal or 0V.

The tables also show the output signals from the micro to the NOR gates and the motor driver enable pins to obtain the correct rotation of the motor.

To synchronise the mechanical rotation of the motor with the software, the motor's Hall sensors deliver three logic signals that are shown in the tables under the headings of RA0, RA1 & RA2. These signals tell the software when the motor poles rotate past certain points. An LM324 op amp is wired as three comparators to sharpen up the edges of the Hall sensor waveforms.

However, in some CD-ROM motors, the Hall sensors are designed to work on a supply of +3V, while others have inbuilt resistors in series so that they can be connected to +5V. Hence, it is wise to check for these resistors before deciding what drive voltage should be used.

Les Kerr,
Ashby, NSW.

Les Kerr is this month's winner of a $150 gift voucher from Harbe & Farbes

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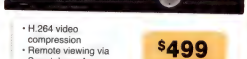

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$149

DOUBLE POINTS

60W ESD Safe Solder/ Rework Station

Complete solder/desolder station for production and service use. Temperature is easily adjusted in 1° increments with simple up/down buttons and the soldering/rework functions can be operated independently of each other.

- Microprocessor controlled
- Temperature range 160°C to 480°C
- Size: 225(L) x 215(W) x 155(H)mm

TS-1574

$299

DOUBLE POINTS

For spare tips and accessories, see website for details.

2:1 Heatshrink Tubing

High quality and VW-1 flame retardant heatshrink tubes. Shrink easily with a heatgun, hairdryer or gas burner.

FROM $5.45

- Black colour
- Available in 7 sizes
- Sold in 5m handy pack

1.5mm Diameter	WH-5680	$5.45
2.5mm Diameter	WH-5681	$6.45
3.0mm Diameter	WH-5682	$6.95
5.0mm Diameter	WH-5683	$8.95
10.0mm Diameter	WH-5684	$10.95
16.0mm Diameter	WH-5685	$14.95
20.0mm Diameter	WH-5686	$21.95

NEW

Also available in red colour. See website for details.

Precision Compression Crimping Tool

This crimper provides reliable, troublefree compression of BNC, RCA, IEC, Min-F and F-type coaxial connectors. Features adjustable compression depth that provides desired crimping length.

- Works with RG59 and RG6 coaxial cables
- 146mm long

TH-1800

$19.95

Super Heavy Duty Copper Cable Shears

Features a precision cutting head forged from carbon steel attached to drop forged steel handles for extra leverage. Cuts copper cable up to 35mm² and any cable up to 2GA.

- 310mm long

TH-1900

$24.95

NEW

WORKBENCH BUNDLE PACK

A must have in your workshop or factory! This package includes the essential items you need to do any repair work without straining your eyes. See website for full specifications.

$129 **SAVE $55.35**

GREAT BUNDLE PRICE!

Kit includes:

Electronic Cleaning Solvent 175g	NA-1004	$11.50
Anti-static Wrist Strap 1.8m	TH-1780	$13.95
Anti-static Desk Mat 555 x 290mm	TH-1783	$19.95
PCB Holder with Movable Arm	TH-1980	$19.95
Desk Mount LED Magnifier Lamp 3-Dioptre	QM-3546	$119

Total valued at over $180!

WORKBENCH BUNDLE DEAL $129

DEAL INCLUDES NA-1004,TH-1780,TH-1783, TH-1980 & QM-3546

SAVE $55.35

TRADIES BUNDLE PACK

No more frustrations with the confusion caused by storage problems! These easy-to-use tool storage belt and boxes can help you get organised quickly. See website for full specifications.

$49 **SAVE $25.85**

GREAT BUNDLE UNDER $50

Kit includes:

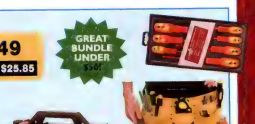
Leather Tool Utility Belt	HB-6373 $19.95
7-Piece 1000V Screwdriver Set	TD-2022 $24.95
12-Compartment Storage Cabinet	HB-6301 $29.95

Total valued at over $70!

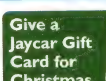
TRADIES BUNDLE DEAL $49

DEAL INCLUDES HB-6373,TD-2022 & HB-6301

SAVE $25.85



Note: Accessories not included



"Smart" Test Screwdriver

A hi-tech screwdriver to help you safely check or test AC/DC voltages, circuitry continuity/polarity, microwave leakage and more! Batteries included.

TD-2055

$11.95

7.5A Heavy Duty Tinned Copper Hook-Up Cables

Flexible heavy duty tinned copper cables with high temperature rating suitable for general purpose, automotive and marine applications.

- Rated to 180°C
- Sold in 10m handy pack

Red	WH-3035	$12.95
Black	WH-3037	$12.95

$12.95 ea

NEW

POWER UP YOUR CHRISTMAS

Non-Contact AC Voltage Detector

A must have for every toolbox. Detects AC voltages from 50 to 1000V. The unit will glow green when safe, and flash red and beep when voltage is detected.

- CAT III rated
- LED flashlight function
- 2 x AAA batteries included
- Size: 158(L) x 23(D)mm

QP-2268

$19.95

Power Point and Leakage Tester

Test your power points using this versatile tester. It checks most types of power points within 110V to 240V for correct wiring and earth leakage circuit breaker trip levels.

QP-2000

$19.95

50A Anderson Connectors

FROM $12.95

Easily adapt or extend your 50A Anderson™ connector with the following options. All adaptors include 300mm cable length.

Eye Terminals Adaptor	**PT-4444**	**$12.95**
15A Cigarette Plug Adaptor	**PT-4446**	**$14.95**
15A Cigarette Socket Adaptor	**PT-4448**	**$14.95**
Insulated Battery Clamps Adaptor	**PT-4449**	**$16.95**
2-Way Splitter Adaptor	**PT-4442**	**$29.95**
Extension Lead with 5m Cable	**PT-4440**	**$64.95**

ABS Enclosures with Snap-In Hinged Lid

Made of high impact resistant ABS plastic, these enclosures can withstand wide range of temperature and humidity fluctuations. Snap-in design for easy opening and closing without using any tools.

- Four internal moulded standoffs to mount PCB horizontally

FROM $5.95

Available in 2 sizes, either light grey or black.
HB-6431 & HB-6433 - 91(L) x 79(W) x 45(H)mm
HB-6432 & HB-6434 - 91(L) x 122(W) x 69(H)mm

Grey, 1-Way Cable Entry	**HB-6431**	**$5.95**
Black, 1-Way Cable Entry	**HB-6433**	**$5.95**
Grey, 2-Way Cable Entry	**HB-6432**	**$7.95**
Black, 2-Way Cable Entry	**HB-6434**	**$7.95**

PCB Mount DC Power Sockets

$5.95 ea **NEW**

Black colour DC power sockets with snap-in designs.

Two models available:
0.7mm 2A DC Socket with SPST Slide Switch PS-0532 $5.95
2.1mm 5A DC Socket with SPST Rocker Switch PS-0531 $5.95

3-in-1 Stud Detector

Survey a wall with ease by sliding this handheld detector along the surface. With three modes to sense studs, cables, and metal, this handy device can locate and mark the precise location of the detected item within a wall.

- Automatic calibration
- Requires 9V battery
- Size: 150(H) x 67(W) x 26(D)mm

QP-2283

$24.95 **DOUBLE POINTS**

Also available:
3-in-1 Stud Detector with Laser Level
QP-2288 $49.95 DOUBLE POINTS!

4-Way Powerboard with 2 x USB Ports

This powerboard with surge and overload protection features 2 x USB ports (2.1A total) for fast charging or powering your iPad®, iPhone®, iPod® or other power hungry USB devices.

- 10A, 2400W rated
- Surge current: 6,000A
- Size: 310(L) x 55(W) x 30(D)mm

MS-4073

$22.95

NEW

Efergy Wireless Power Monitors

Extremely easy to set up and use, instantly manage and reduce your power bills now! Once attached to your conventional electricity meter via a wireless sensor/transmitter, these advanced wireless electricity monitors allow you to conveniently view your live power consumption and running costs, or store your usage by day/week/month.

Available in base model or with USB port for data download and analysis. Batteries required.

FROM $99

Elite Base model MS-6200 $99 (Shown)
E2 Classic with USB for Data Download/Analysis MS-6202 $129

Also available:
Engage Home Hub Kit for real time usage on-the-go using an internet enabled smartphone/tablet/PC. Add up to 8 transmitters.
MS-6204 $129

NEW

Waterproof ABS Cases

Black waterproof ABS cases for storing or transporting test equipment, delicate electronic devices, radios and more.

- IPX8 waterproof and shockproof
- Lanyard included

Three sizes available:
182(L) x 120(W) x 42(H)mm
HB-6421 $16.95
182(L) x 120(W) x 75(H)mm
HB-6423 $19.95
655(L) x 482(H) X 495(H)mm
HB-6425 $29.95

FROM $16.95

2.1mm DC Connector Set with Pigtail Leads

Features a standard 2.1(ID) x 5.5(OD)mm DC connection with an IP67 rated coupling. The connectors are supplied pre-fitted to a 100mm pigtail lead, allowing you to make up your own lead set. Very handy on the campsite or in any number of applications.

- Cables are 20AWG
- 3A max at 12VDC

PS-0785

$7.95

Cat iV Heavy Duty True RMS DMM

This heavy duty DMM with IP67 waterproof rating is designed to withstand harsh environments for electrical, industrial and other professional uses. Rugged design and drop proof up to 2 metres.

- Cat IV 600V, 4000 count
- AC/DC voltages up to 1000V
- AC/DC current up to 10A
- Resistance, frequency, continuity, diode, temperature and more
- True RMS for accurate readings
- Autoranging, data hold/min/max recording
- Size: 180(L) x 82(W) x 57(D)mm

QM-1574

$109 **DOUBLE POINTS**

NEW

40A Switchmode Laboratory Power Supply

This high-powered switchmode power supply has a variable output voltage from 3 to 15VDC, or it can be fixed at 13.8VDC. Ideal for test or design environments. Features overload, over temperature and over voltage protection.

- Size: 220(W) x 110(H) x 300(L)mm

MP-3090
WAS $299

$259 **SAVE $40**

SIGN UP NOW & BE REWARDED

Earn a point for every dollar spent at any Jaycar Company store* & be rewarded with a $25 Rewards Cash Card once you reach 500 points!

*Conditions apply. See website for T&Cs

Register online today by visiting **www.jaycar.com.au/rewards**

2-Pin LTW Circular Connectors

IP67 rated connectors perfect for harsh environments such as marine, industrial, outdoor, automotive, etc.

LTW®

- 5A rated

Panel Mount Plug
PP-0542 $8.95
Line Socket
PS-0541 $10.95

4-pin and 6-pin connectors also available. See website for details.

FROM $8.95

Mini LED Driving Lights

With an amazing brightness of 500 lumens or 35W halogen equivalent, this light is an all-round solution for many different applications. Extremely tough built with virtually unbreakable IP68 waterproof and aluminium construction. Shock and vibration resistant. Stainless steel mounting brackets included.

- Input voltage: 9-60VDC
- Beam distance:
  145m (SL-3916) / 50m (SL-3915)
- Compact 70(H) x 40(W) x 55(D)mm
- Sold individually

Spot or flood beam available:
Spotlight SL-3916 $49.95
Floodlight SL-3915 $49.95

$49.95 ea

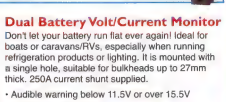
DEAL! BUY 2 FOR $79 SAVE $20.90

12" LED Driving Light Bars

This high power single row LED light bar uses six 10W Cree® XM-L LEDs to produce a whopping 5,400 lumens - equivalent to a 400W halogen. Virtually unbreakable IP68 waterproof and aluminium construction. Shock and vibration resistant. Stainless steel mounting brackets included.

- Input voltage: 9-36VDC
- Beam distance:
  474m (SL-3970)
  316m (SL-3971)

Spot or flood beam available:
Spotlight SL-3970 $249
Floodlight SL-3971 $249



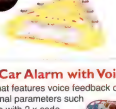
$249 ea NEW

LED Emergency Warning Light

A 9 x LED emergency light with a magnetic base for car breakdowns, campsites, or boating. A must have for that extra visibility during critical situations.

- Light modes: Constant on or flashing
- Requires 3 x AAA batteries
- Size: 140(L) x 140(W) x 35(H)mm

ST-3085



$14.95 NEW

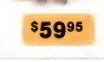
OBD2 Bluetooth Engine Code Reader

No more cables! Read diagnostic trouble codes, both generic and manufacturer-specific with this wireless OBD2 Bluetooth® engine code reader. Save previous time and money by diagnosing and fixing certain problems yourself.

- Works with most OBD2 compliant vehicles

PP-2145

See website for more details and list of supported vehicles.



$59.95 NEW

Dual Battery Volt/Current Monitor

Don't let your battery run flat ever again! Ideal for boats or caravans/RVs, especially when running refrigeration products or lighting. It is mounted with a single hole, suitable for bulkheads up to 27mm thick. 250A current shunt supplied.

- Audible warning below 11.5V or over 15.5V

MS-6176 WAS $149

$119
SAVE $30

Steelmate Basic Car Alarm with Voice Function

An affordable car alarm that features voice feedback on alarm status and operational parameters such as open doors etc. Comes with 2 x code hopping remotes. Other features include boot release button, valet mode, and manual override.

LA-9003

$99

Spare remote LA-9004 $37.95

DEAL! BUY LA-9003 + LA-9004 FOR $109

GPS/GSM Vehicle Tracking Device

Locate and track the whereabouts of your vehicle in real time via the Internet on a computer or Smartphone. It works by sending the vehicle's GPS coordinates via the GSM network (Sim card not included) to the free online tracking service, which shows the location on Google Maps.

- Built-in GSM & GPS antenna
- Features remote engine immobilisation, SOS/panic alerts, over speed or area detection alerts
- Very low 1 to 2mA standby current
- Size: 68(L) x 48(W) x 20(D)mm

LA-9011

$149
DOUBLE POINTS

Heavy Duty Panel Mount Circuit Breakers

These high quality panel mount circuit breakers with multi-wire gauge inputs and outputs are perfect for high end car audio installations, automotive wiring or solar installations.

- Platinum plated terminals
- Size: 85(W) x 68(H) x 35(D)mm

60A	SZ-2081	$34.95
120A	SZ-2083	$34.95
200A	SZ-2085	$34.95

$34.95 ea NEW

Portable Pure Sine Wave Inverters

Suitable for a variety of mobile and permanent power installations, these inverters offer standard protection (overload, high temperature, over/under input voltage and output short circuit) as well as host of additional features to improved performance and reliability under adverse conditions. Range from 180 to 2000W.

- USB port
- 12VDC input, 230VAC output

180W	MI-5700	WAS $199	NOW $169 SAVE $30
360W	MI-5702	WAS $239	NOW $199 SAVE $40
800W	MI-5704	WAS $449	NOW $369 SAVE $80
1100W	MI-5706	$599	NEW LOWER PRICE
1500W	MI-5708	$799	NEW LOWER PRICE
2000W	MI-5710	$999	NEW LOWER PRICE

FROM $169
SAVE UP TO $80

4.2A USB Car Charger

Charge up to 3 USB devices as you drive. Includes a 2.1A USB port, 1A USB port and a 1A micro-USB plug on a 500mm lead, which can be neatly stored away when not in use.

- 12/24VDC

MP-3665

$19.95 NEW

Also available: 1m USB Charge Lead for Apple® Devices WC-7693 $7.95

DEAL! BUY MP-3665 + WC-7693 FOR $21.90

Handsfree Car Kit with FM Transmitter & Bluetooth

Take calls or stream music via the car radio from your Smartphone, USB or load songs onto a microSD card (sold separately 32GB XC-4992 $47.95).

- 12/24VDC
- Powered by cigarette lighter socket
- Includes USB charging port (1.0A)

AR-3132

$39.95

Rechargeable Handsfree Car Kit with Bluetooth

Plugs into the car's MP3/AUX 3.5mm jack for hands free functionality with any Bluetooth® enabled Smartphone.

- 12/24VDC
- Up to 4 hours of use per charge
- Rechargeable using the supplied car charger

AR-3130

$39.95

CHRISTMAS PARTY ESSENTIALS

Karaoke Style Microphone Mixer

A compact unit that converts your CD/DVD player into a karaoke system to sing your heart out. Features separate microphone volume levels, tone and variable echo control. Includes 2 microphones with cables and a 12V power adaptor.

- RCA phono inputs/outputs
- Size: 140(W) x 90(D) x 40(H)mm

AM-4222

Works with any 600 ohm dynamic mic, see website for more details.

$69.95

Wireless UHF Guitar Link

Enjoy the freedom of practicing or performing without wires. Crystal-clear UHF wireless guitar system with a range of up to 60m. Compact PA transmitter and receiver. Includes sturdy ABS box, 6.5mm adaptor lead, AC adaptor and instructions.

- Selectable 520.5MHz or 532.9MHz
- Retractable telescopic antenna
- 1 x AAA battery required

AM-4109

$89.95

2 Channel Wireless UHF Microphone System

Ideal for large events, this UHF system offers greater wireless range of up to 60m with less interference and fewer dropouts than in a VHF system. Features level controls for each channel to balance the vocals separately as desired. Includes 2 microphones and power adaptor.

- Receiver output: 1 ch balanced/2 ch unbalanced mixed
- Batteries required

AM-4114

Accessories available separately.

$119

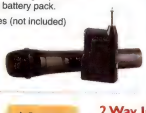
Single Channel Wireless UHF Microphone

An easy to use UHF Wireless Microphone system perfect for a wide range of applications. Effective range up to 50m. Supplied with USB rechargeable battery pack.

- Also powered by 2 x AA batteries (not included)

AM-4108

$69.95



8" Rechargeable Wireless PA System

Get the party started anywhere with this all-in-one compact sound system with built-in UHF wireless receivers and MP3 player. Play tracks via Bluetooth® or USB/SD/AUX inputs. Includes one lapel mic and UHF belt pack transmitter.

- 40WRMS rated
- Up to 8 hours of use per charge
- Audio inputs: XLR, 1/4", RCA, 3.5mm
- Audio output: 1/4" phone jack
- Very portable, only 8kg
- Size: 320(W) x 310(D) x 455(H)mm

CS-2510 WAS $349

$299

SAVE $50

4" Communication Speaker

A powerful waterproof speaker to connect to CB radios and other communication devices for clearer audio reproduction. Mounting accessories included.

- 15W, 10WRMS
- Size: 108(L) x 108(W) x 62(D)mm

AS-3187 WAS $29.95

$24.95

SAVE $5

2 Way Indoor/Outdoor Speakers

Add quality surround sound to your indoor or outdoor areas around the workshop, patio or any room. These 2-way weather resistant speakers are made of heavy duty ABS plastic to suit outdoor climate. Mounts vertically or horizontally for perfect sound projection.

- Sold as a pair

Refer to website for dimensions and full specs.

4"	25WRMS CS-2475	WAS $69.95	NOW $54.95	SAVE $15
5"	30WRMS CS-2476	WAS $79.95	NOW $64.95	SAVE $15
6.5"	40WRMS CS-2477	WAS $99	NOW $79	SAVE $20
8"	50WRMS CS-2478	WAS $149	NOW $119	SAVE $30

FROM $54.95

SAVE UP TO $30

Speaker Ceiling/Wall Bracket

This sturdy and versatile steel bracket can be adjusted by the main axis (over 180˚) and minor axis (360˚). Includes a steel wire lanyard for extra safety which makes it ideal for professional PA installations.

- Holds up to 10kg
- Speaker plate: 80(W) x 45(D)mm
- Sold individually

CW-2841

$22.95

DEAL! BUY 2 FOR $35.90 SAVE $10

Speaker Extra Heavy Duty Tripod Stand

This rugged stand extends to approx 2m and will support speakers, combo amps, lighting rigs up to 45kg. Made from strong aircraft grade aluminium for easy transportation and long service life.

- Support base max 111cm

CW-2860

$99

DOUBLE POINTS

TV Ceiling Mount Bracket

Don't pay too much for quality mounting brackets. This heavy duty 280 x 280mm ceiling mount plate will safely and securely hold the TV in place.

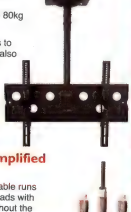
- Tilt and rotate for maximum viewing flexibility
- Solid aluminium and steel construction
- Suits 32" to 60", up to 80kg

CW-2855

Wall mounting brackets to suit 23" to 60" TVs are also available. See website for more details.

$149

DOUBLE POINTS



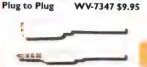
3.5mm 4 Pole AV Connectors

Also known as TRRS connectors, suitable for use in AV applications, iPhone® and many camcorders.

- Both units include 2m lead

Plug to Socket WV-7349 $9.95
Plug to Plug WV-7347 $9.95

$9.95 ea



Dual Core Speakon Audio Lead

Speakon connectors are now the standard for PA and sound reinforcement applications. Excellent ready-made cable assemblies.

5m WA-7100 $24.95
10m WA-7102 $34.95

FROM $24.95

High Quality Amplified HDMI Leads

Achieve longer HDMI cable runs using these amplified leads with built-in equaliser. All without the need for a power supply.

10m WQ-7430 $79.95
15m WQ-7432 $99
20m WQ-7434 $129

FROM $79.95

Rechargeable 2-Channel Wireless Camera Kit with 4.3" LCD

GREAT GIFT UNDER $100

Truly portable multi-purpose camera kit with exceptional unobstructed range of up to 250m! Suitable for virtually any application in the car, home or camping. Mains adaptor and cigarette lighter cable included.

- 2.4GHz digital wireless
- Infrared night vision
- Suction cup mounting
- Up to 5 hours of use per charge

QC-3217 ~~WAS $139~~

$99 SAVE $40

Spare camera QC-3211 $79.95

4-Channel Wireless Monitor Kit with 7" LCD

Featuring two-way speaker and highly sensitive microphone, this camera kit is ideal for baby monitor, home and small business security. Mains adaptors and AV cable included.

- 2.4GHz digital wireless
- Infrared night vision
- VOX function

QC-3649 ~~WAS $169~~

$139 SAVE $30

Spare camera QC-3648 $79.95

LCD Alarm Clock with Temperature & Calendar

With clearly visible size and stylish design this LCD alarm clock is ideal for your home or office workspaces.

- Temperature in Celsius or Fahrenheit
- Requires 2 x AA Batteries
- Size: 280(W) x 190(H) x 25(D)mm

XC-0221

$39.95

Give a Jaycar Gift Card for Christmas

UV Sanitiser Toothbrush Holder

The hygienic bathroom solution! Ultraviolet rays sterilise up to 4 toothbrushes to remove odours and stop the build up of potentially harmful bacteria. Includes drip tray and toothpaste holder.

GH-1191

$49.95

Pedometer with Bluetooth Technology

Add another dimension to your exercise with this tiny pedometer. Track your steps, distance and milestones even when your Smartphone isn't on you.

- USB Rechargeable
- Data viewable via free iOS App
- Size: 38(L) x 30(W) x 9(H)mm

XC-0390

$34.95

DEAL! BUY 2 FOR $49 SAVE $20.90

Heart Rate Monitor with Bluetooth Technology

Monitors your heart rate to ensure you are optimising your exercise. One-piece design, simply wear on the chest and it will wirelessly transmit heart rate information to a Smartphone or Tablet via Bluetooth®. Track your heart rate, calories burned, distance, speed, and more.

- Pulse rate range: 30 - 239bpm
- Data viewable via free iOS or Android App
- Buckle size: 64(L) x 40(W) x 12.9(D)mm

XC-0392

$49.95

DEAL! BUY 2 FOR $79 SAVE $20.90

Multifunction Camping Radio

A device of many talents. Crank the dynamo handle to charge the built-in batteries power torch, music player, AM/FM radio and smartphone charger! It also features blinking mode and siren in an emergency. Perfect for a camping or road trip.

- Also plays MP3 on USB/SD card
- USB port to charge a Smartphone
- Size: 190(L) x 125(W) x 90(D)mm

ST-3356 ~~WAS $59.95~~

$49.95 SAVE $10

Automatic Wrist Blood Pressure Monitor

Monitors blood pressure and heart rate from the wrist. Designed to take accurate blood pressure readings and calculate the average blood pressure.

- Uses the oscillometric method
- Arrhythmia detection function (IHB)
- Stores readings for up to 3 individuals
- Requires 4 x AA batteries

QM-7254 ~~WAS $49.95~~

$39.95 SAVE $10

Automatic Upper Arm Blood Pressure Monitor

This pressure-cuff unit fits on your upper arm like the ones you find in most doctors rooms. It will measure 30-280mm mercury, and 40-195 pulse.

- Accuracy: 3mm Hg, 5% of pulse
- Displays date/time, systolic, diastolic and pulse rate
- Requires 4 x AA batteries

QM-7261

$59.95 DOUBLE POINTS

Note: This is not a medical diagnostic device and is intended to provide indicative readings only. It should be used in conjunction with advice from a doctor or other clinical professional.

GREAT GIFTS UNDER $20

Nifty LED Torch with Telescopic Neck

A pen-sized torch with super bright LEDs and magnetic head for picking up objects. Extendable to 546mm and gooseneck at the end allows light to be shone around corners, into cracks and crevices.

- Size: 165mm long to 546mm extended
- Includes 4 x LR44 batteries

ST-3463

$12.95

Handy Magnet Strip

Very impressive holding strength! Attach the handy magnets to walls, tables or other surfaces to hold tools, brushes, scissors, key rings or any other object that contains iron.

- 9 piece magnet, each holds up to 1kg
- Size: 750(L) x 25(W)mm

LM-1624 ~~WAS $19.95~~

$14.95 SAVE $5

Note: Tools not included

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This clever unit not only measures temperature and humidity, it also shows on a simple scale just how dangerous the environment is.

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KJ-8960

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NEW

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This handy module ensures your project is still running by watching for a "heartbeat" signal and kicking it back into life if the signal stops. Ideal for projects that are mounted in hard-to-reach places and need to keep running with long term reliability.

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XC-4267

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This stunning 3D-matrix of 64 RGB LEDs incorporates an onboard Arduino-compatible controller. Create mesmerising light shows or build your own "ambient device" that gently notifies you of new email or instant messages. Some assembly required.

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XC-4274

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This handy device allows you to connect your 15A devices (welder, compressor, etc) to any 10A domestic power socket. Features a 10A circuit breaker/RCD in case you accidentally overload the device. A must have for handyman and tradies.

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MS-4044

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MB-3607

See our website for the full list of features and specs.

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YN-8348

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NEW

3W VHF Marine Radio

Essential for boating. Covers all international VHF marine channels so you can call for help when needed or communicate with other boats. Includes a Li-ion rechargeable battery pack, AC adaptor, charging cradle and belt clip.

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Prices valid from 24th November 2014 to 23rd December 2014.

Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

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This hand-held instrument combines several different functions including single-channel CAT III oscilloscope, CAT III multimeter, data logger, 8-channel logic analyser with protocol decoder and pattern generator in one hand-held, battery-powered instrument. If you can only carry around one instrument in the field, this one's for you.

WENS 540 Debug Meter

Continuing the trend of combining multiple functions into one test instrument, this is a step closer to "nirvana" where one device does everything.

Sometimes that means making a lot of compromises but in this case it seems that the manufacturer (WENS) has struck a fine balance of functions, convenience and performance.

The WENS 540 is a little bigger than your average multimeter, at 100mm wide, 220mm high and 54mm deep. It weighs 800g so it isn't difficult to hold or carry for short periods.

It's certainly much more convenient than the larger portable scopes which are definitely two-handed affairs. The built-in tilting stand makes it also convenient for desk-top use.

WENS haven't cut corners on the multimeter, as can sometimes happen with multi-purpose instruments. The functions include DC volts (50mV-1000V), AC volts (50mV-1000V True RMS), or AC+DC volts (500mV-1000V True RMS), AC, DC or AC+DC current (500µA-10A), resistance (50Ω - 50MΩ), continuity, diode test, capacitance (5nF-500µF) and frequency/duty cycle (100kHz-3MHz). It can also display temperature if a thermocouple is connected (not supplied).

In DMM mode, it has a large 50,000 count display. Thus the finest resolution available in each mode is 1µV for voltage, 10nA for current, 1mΩ for resistance, 1pF for capacitance and 1Hz for frequency.

In many modes there is also a bar graph display so you can see rapid changes in the readings. It also has min/max/average display, peak hold and auto or manual ranging, plus some intriguing features we haven't seen in other devices, such as a ripple voltage or ripple current measurement up to 100kHz.

Overall reading accuracy is quite good, at ±0.025%+10 counts for most voltage readings, ±0.15%+10 counts for most current readings, ±0.05%+30 counts typical for resistance and ±1%+10 counts for typical capacitance readings.

In terms of features and accuracy then, it's comparable to a good quality mid- to upper-range dedicated multimeter.

And like some of the more expensive multimeters it also

Review by Nicholas Vinen

has a data-logging mode, where it stores up to 10,000 measurements. You can then download these measurements to a PC via the USB connector.

But because of the graphical LCD, you can actually do quite a bit of analysis on-screen if you prefer.

Oscilloscope mode

Even though it only has a single channel and lacks the colour screen of a dedicated DSO, the oscilloscope functions of this device are better than you might expect from such a small unit.

It has 10MHz bandwidth and does up to 50 megasamples per second. Inherent noise is low and the screen is updated many times per second.

The sensitivity range is quite wide, from 20mV/div to 100V/div. There's no "probe" attenuation since the inputs are banana sockets, so this whole range is usable. Noise is low, even at maximum sensitivity. Input coupling is AC or DC and there are two acquisition modes, sampling or peak.

Trigger options are Edge or Pulse and can be set for rising/falling/alternate/either edge and positive/negative pulses. Trigger modes are Auto, Normal or Single.

A number of measurements are available including mean and RMS voltage, frequency, period, pulse widths, peak-to-peak voltage, minimum and maximum voltage and total amplitude. Up to four measurements can be displayed and there are also manual cursors available.

The unit's memory is only 1kpoints so basically, you can freeze what you see on the screen and that's about it. Still, it's quite useful for such a small unit.

Logic and protocol analyser

The logic analyser "head" provided is great since it is easy to plug in and has multiple, colour-coded, permanently attached "IC clips" at the other end of a decently long cable. While logic heads with detachable clips have some advantages, they have the distinct disadvantage that if you bump your set-up they can come loose, so these ones get a thumbs-up.

The main cable connector is basically a standard pin-header socket with some pins missing so you could easily make up a cable to connect the unit to a row of test headers on a PCB, which we think is a nice touch.

Regarding the supplied cable, in addition to the eight logic channel clips (blue), which are labelled with their channel number (nice!) and black ground clip, there are red and black alligator clips for the adjustable square wave output (10Hz-1MHz, 5V fixed amplitude, 5-95% duty cycle) and the transmit/receive IC clips (red) for the pattern generator.

The pattern generator is used primarily to inject a 3.3V serial stream into the device under test (DUT) using logic-level serial (RS-232), CAN or some other arbitrary serial bus and then observe and decode the response on another signal line.

You can store up to eight patterns in the device and the signal polarity is selectable. The display shows any serial data received while transmitting the selected pattern.

We would have liked some other protocol options such as I²C and SPI but that would require more than one output line. As it is, this could definitely be a useful feature, especially if you are trying to debug a device in the field which has a serial configuration interface (a pretty common situation).

Getting back to the logic analyser itself, it can operate on signals up to 10MHz (with a sampling rate of 50MHz) and also has a 1kpoint memory (per channel). It can handle signals up to 10V and the low/high threshold is around 0.7V (ie, one diode drop) so it's suitable for use with just about any low-speed signalling scheme.

Supplied accessories include the carry case, probes as shown (including 14-way clip leads), a USB cable and an approved plugpack/charger. There's a range of optional accessories available to suit specific tasks.

The protocol analyser (supplied as standard) can decode many different kinds of serial signals including CAN, LIN, I²C, UART, USB (low/full speed), I²S, SMBUS, SPI, DMX512 and Dallas 1-Wire. That's a comprehensive list.

Trigger options depend on the serial bus being decoded. For example, for USB, you can trigger on start of packet (SOP), end of packet (EOP), reset complete (RC) or entering or exiting suspend mode.

You can't choose which logic channels go where, but it does show you how to hook it up. For example, in SPI mode, probe one goes to MISO (Master In, Slave Out), probe two to MOSI, probe three to SCK (clock) and probe four to SS-BAR (Slave Select, active low).

The remaining channels can then be used to monitor any other digital signals in the circuit you may be interested in. These can also be used to trigger the logic/protocol analyser, if you don't want to trigger on serial bus events. Some of the decoders have extra options, for example, in SPI mode you can change the clock polarity and there are a few different SPI variants such as "Microwire" which are also supported.

Overall this is a pretty flexible logic analyser, with the main limitation being that there is no mixed signal mode, ie, you can't use the scope and logic/protocol analyser functions simultaneously.

PC software

The supplied Windows software works well – see the accompanying screen shot. It shows a live view of the device's screen, so you can save images and so on.

You can also control the device, with a similar interface to the unit's own buttons and you can easily start and stop logging data and then save that data to your computer. It's basic but it's a fast, no-fuss way to get data off the device.

The unit is powered from a build-in rechargeable NiMH pack and is charged using an Australian-made approved plugpack (supplied). Battery life is good and based on our

experience, the claimed eight hours on a single charge is plausible. They do not give a figure for shelf life though. If it's a low self-discharge type NiMH pack then it should hold its charge for several months (even with occasional use) but we didn't have the unit for long enough to test this out.

Conclusion

Overall, the WENS 540 is easy to drive and if you're reasonably familiar with other test equipment, you'll figure it out after just a few minutes of use.

As a multimeter, it works well and is similar enough to other meters that just about anyone can pick it up and use it.

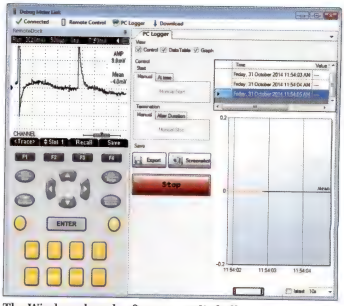
As a scope, its functions are quite simple but nonetheless useful. Boot-up time is quick; it only takes a second or so to switch on and be ready for use.

The WENS 540 is supplied with a number of standard accessories including probes (decent quality), the logic "head", mains charger, USB cable, multi-compartment carrying case with shoulder strap, user manual and software/documentation CD. . . basically, everything you need.

So in a nutshell, if you need a test instrument that you can easily carry around with you, or you don't already have much test equipment and want to buy a single unit that will serve you well in a variety of different test and debugging situations, the WENS 540 would be a good choice at $795 + GST.

If you do a lot of field servicing or even at a workbench, there are certain advantages to a unit like this: less clutter, more room to work with the device under test, easier to move around (no mains cord) and so on.

In fact, if you carry around the WENS 540 and a good LCR meter with ESR and impedance measurement, you can do just about any electronic test or measurement you might possibly need out in the field, with room left in your glove box.



The Windows-based software supplied allows live control and logging over USB. Stored waveforms and screenshots can be transferred to the PC this way.

For more information

To purchase one of these units, or even if you'd like more information, contact Trio Test & Measurement on 1300 853 407, e-mail sales@triotest.com.au or visit www.triotest.com.au/shop/en/237-handheld

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SERVICEMAN'S LOG

We're genetically programmed to fix things

Dave Thompson*

One of the great things about being a serviceman is that we get to work on a wide variety of jobs. This also carries over into our hobbies and repairing or modifying stuff for family and friends. But it can also be a curse; if we come across something that needs fixing, it seems that we are genetically programmed to have a go at it.

Most of us assembled kits or scratch-built projects from magazines when we were youngsters and carried this interest over into adulthood. In many cases, we subsequently turned it into our full-time work. And while most of us obviously don't build projects for a living, the skills gained in putting those kits together laid the foundations for our servicing work.

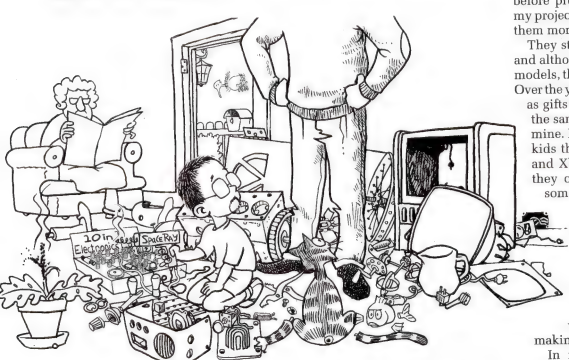
As a kid, I had a tendency to pull stuff apart, mainly because I was interested to see how it all worked. But while there was usually a method to my disassembly, I sometimes couldn't quite get things back together again. More than once, Dad either stepped in and did it for me or patiently showed me how to do it and then let me have a go.

A classic example was an old valve radio that I pulled apart and then, for the life of me, couldn't get the complicated dial cord installation back the way it was. Dad helped out by going through it with me until we had it right. As an electronics hobbyist and amateur and CB radio buff, Dad was always doing something in his workshop and I used to hang out there while he worked on his various projects.

He must have recognised my interest because on one of his trips away he brought back one of those "10 in 1 electronics labs" for me to play with. It had a bunch of electronic components mounted on a colourful printed board with the component's circuit symbol and name above it and little springs corresponding to the component leads. A resistor, for example, had two springs, a transistor three, the tuning capacitor four and so on.

By connecting short lengths of the supplied hook-up wire to the springs, I could build the likes of a single transistor radio, a Morse-tone oscillator, an audio amplifier and a handful of other simple circuits, learning about them as I went. I loved this kit and spent many fascinating hours playing with it. After a while, I was adding components and making more than the 10 basic circuits before progressing on to assembling my projects on Veroboard and making them more permanent.

They still sell similar things today and although some are now "40 in 1" models, the basic premise is the same. Over the years, I've given a few of these as gifts to kids and hoped they got the same joy out of it as I did with mine. However, it seems that most kids these days want Playstations and Xboxes rather than a kit that they could use to actually make something.



AS A KID, I PULLED STUFF APART & SOMETIMES COULDN'T GET THINGS BACK TOGETHER. MORE THAN ONCE, DAD STEPPED IN & DID IT FOR ME OR PATIENTLY SHOWED ME HOW TO DO IT.

Modifying cars

One particularly fertile area of interest for the hobbyist or "DIYer" is cars. This not only involves fixing things when they go wrong but also involves adding gadgets and/or making useful modifications.

In fact, car-related electronic projects are so popular that entire books have been dedicated to describing them. Whether it's adding

a new electronic ignition system or a simple courtesy light extender, most servicemen love tinkering with cars and I'm no different.

I've owned a variety of vehicles over the years and I've modified every one of them in some way – hopefully for the better. I got the bug from Dad who always improved his cars by adding the likes of radios, electric sunroofs, cruise control, overdrives or some other often-complicated modification, simply because most NZ-assembled cars didn't come equipped with these features as standard.

I vividly recall one particular (non-electrical) modification that Dad did for some Triumph models which he and others owned. It involved installing Indian Rubber balls in the suspension in an effort to improve the geometry and overall ride comfort!

These days, with the advent of the information superhighway, people can share their projects and modifications with other like-minded individuals all over the world, typically in dedicated forums and websites. This usually means that no matter what you want to do to your car (or motorbike), chances are that someone else has already done it for themselves and has uploaded a detailed guide or walk-through to the net. Going through these guides is a great way to avoid making the same mistakes that others have made along the way.

Popular modifications

If you are lucky enough to own a late-model car with all the bells and whistles, there's probably not much you can do to improve or personalise it. However, for those of us who drive old cars, there's often no end of improvements and modifications that can be made to improve performance or to make them more user-friendly.

Popular modifications in the past included adding rear-window heating, a courtesy light extender, a wiper delay unit and even an electronic ignition system. And while most cars less than 15 years old already have these features installed, some won't and these and older vehicles can certainly benefit from having this stuff fitted. In my case, I've carried out a few worthwhile modifications to my existing car, an MG-F roadster. The first involved the keyless entry system. Out of the box, the range of the key fob is about two metres and while this is fine for most situations, it doesn't help when you are warm and snug inside on a windy and rainy night, wondering if you've locked the car.

Before modifying it, I had to run out into the weather in order to be close enough to operate the lock. It's interesting to note that the old trick of holding the fob under your chin while operating the buttons actually does increase the range (presumably, because the head acts as a resonant cavity). However, it only adds a couple of metres at most and this is often not enough.

After searching through various websites that deal with my model car, I found a couple of modifications that could be easily carried out and which would make a world of difference. The first involved altering the position of the RF antenna in the car.

This antenna, which is just a heavy piece of wire, is coiled up behind a panel in the passenger's foot-well. Undoing a couple of screws allows this panel to be removed, so that the antenna is revealed. On my car, it's a yellow wire and simply straightening it out horizontally and cable-tying it to a handy nearby alloy bracket effectively doubles the range of the key fob.

Someone had also gone a step further and worked out that the 433MHz operating frequency has a wavelength of about 70cm. The standard antenna wire measures 17.5cm, or one quarter wavelength. Adding another 17.5cm length to the wire makes it a half wavelength long, while adding another 52.5cm makes it a full wavelength.

This should increase the range accordingly but I didn't go to that extreme. That's because the wire has to be routed carefully to ensure it doesn't foul any of the heater controls. In my case, I just straightened the wire because I intended to do a second modification which would also add range.

This involved extending the antenna in the key fob, which was as easy as popping open the fob with a screwdriver blade, finding the antenna track on the PCB and soldering a length of light-gauge hook-up wire to it. The length of this wire can also be calculated but it turns out that you get close to the ideal length simply by coiling the wire and doubling it back around a certain path inside the fob.

So that's exactly what I did. The range on a good day with a tail-wind is now about 15 metres. And that's more than enough to lock my car from inside the house on those cold, stormy Christchurch nights.

Fan-speed controller

Another worthwhile modification to the MG-F involves improving on the design of the speed controller for the fan/heater blower. One of the more well-known issues with this vehicle is the fragility of this controller and many an MG-F is now missing the first two settings on the 5-way blower switch.

Most people don't bother with this but as I said earlier, a serviceman is genetically disposed to fixing things and this was no exception. Positions 1 & 2 on my fan control did nothing and a quick search on the forums soon explained why.

Part of the system involves a resis-

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Items Covered This Month

- Programmed to fix things
- Intermittent internet connection
- HP LaserJet 1320N
- Industrial machine servicing
- Teac TV antenna connector
- Using mains cable for low-voltage wiring can be dangerous

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No Internet: Is It A Faulty Router Or A Faulty Cable Modem?

An intermittent or slow internet connection can be a real pain in the you-know-what, especially if it also sometime works perfectly, thereby complicating the troubleshooting process. What's more, diagnosing such a problem can be even more complicated if a separate router and modem are used, as G. I. of Dural NSW found out. Here's what happened . . .

For several years, my internet connection was based solely on a Motorola SBG900 cable modem/router, with a Wireless-G WiFi connection to a PC in a different room. The modem sat behind the TV set in the family room and was connected to the Telstra cable via a 2-way splitter, along with a Foxtel cable box.

This worked well but following the acquisition of a smart TV, an updated Foxtel IQ box and other gear, the day came when I needed more than the single ethernet port offered by the Motorola cable modem. My solution was to add a Netgear WNDR3700 4-port router to the setup. This is a dual-band gigabit router and as a bonus, it also included Wireless-N (802.11n) WiFi.

Installing it was straightforward. It was just a matter of setting up wireless networking on the new router, turning on NAT (network address translation) and setting the DHCP range. Conversely, these functions were all disabled in the Motorola SBG900, so that it now functioned as a modem only. The downstream port from the router was then linked to the modem via a network cable and the system reconnected to the Telstra cable.

While I was at it, I also substituted a Wireless-N USB adaptor for the wireless-G adaptor on my PC, so that I could take advantage of the higher speeds offered by 802.11n WiFi.

It all worked like a dream for several years until about three months ago, when I noticed that certain websites were taking a long time to load. Restarting the system had no discernible effect on this and then, a couple of weeks later, it conked out altogether, with no internet access. The WiFi connection between the PC and the Netgear router still worked though and I was still able to connect to other devices, such as IP cameras, on the local network.

Restarting the cable modem made no difference so I tried restarting the router. I then found that I again had internet access, although some sites was still slow to load. But was it a faulty router or was it a faulty cable modem that was taking its time to connect to the Bigpond server and authenticate itself?

The system subsequently conked out again about a week later and this time, restarting the system had no effect at all. I tried swapping the network cable between the router and the cable modem but that didn't fix it.

Suspecting a faulty router, I removed it and just went back to the cable modem. The result was that I now had full-speed internet access again, so it looked like the router was indeed faulty.

The router was now about four years old, so it was well and truly out of warranty. However, the Netgear WNDR3700 is quite a nice unit, so before discarding it and lashing out on a new one, I decided to see if it could be fixed. Faulty electrolytic capacitors are a common problem in this type of equipment and it's always worth checking these out.

Removing six Torx-head screws allowed the case to be opened. The router's PCB was then removed by lifting it off its mounting posts and a quick inspection revealed that there are only four electrolytic capacitors in the unit – a 470µF 25V capacitor across the incoming DC supply rail and three 470µF 16V capacitors in

tor pack consisting of three coils of Constantan resistance wire. Their resistance values determine the speed of the blower fan, so its basically a very simple system.

In practice, the three different gauge coils are cleverly positioned in the ducting, so that air flowing through the system keeps everything cool. Unfortunately, it seems that this design is inadequate because due to vibration and constant heating and cooling, the lighter coils for the two lower settings typically break and end up floating around in the ducting, causing a most annoying rattle.

Gaining access to these coils is a bit fiddly but eventually I decided that it was a job that just had to be tackled. Knowing that something wasn't working was bothering me and what's more, I was fed up with the rattle.

The resistor pack is accessed by first removing the glove-box on the passenger side. That done, I was able to dig around among the various wires and ducts until I spotted a white plastic Molex-type plug connected to a black plastic box mounted into one of the air-ducts. Two Phillips-head screws

other locations on the board.

Two of the latter were next to each other and adjacent to an area covered by a metal shield. This was presumably the WiFi circuitry and those two capacitors appeared to be part of a power supply inverter circuit.

The capacitors were all good-quality 105° units and they looked to be perfectly OK. Certainly, there were no tell-tale bulging tops to indicate that they were faulty but I decided to take a punt and change them anyway.

I replaced the 25V unit across the supply rails first and then moved on to the two 16V units adjacent to the metal shield. Their solder pads on the underside of the PCB were covered by a plastic shield and this was aligned with the metal shield on the top. And when I swung this plastic shield out of the way to access the pads, I immediately spotted what I thought could be causing the problem – a bad solder joint.

As the photo shows, the solder around one of the capacitor leads had failed to correctly adhere to a substantial section of its copper pad. Instead, it had formed a blob on the lead itself but the connection to the rest of the pad appeared to be OK. On the other hand, the solder had a rather "frosty" appearance, so it was just possible that this joint had gone high resistance, effectively taking the capacitor out of circuit.

I replaced the capacitor, this time taking care to ensure a good solder joint. I then changed the remaining two capacitors, after which the router was reassembled and reconnected to the cable modem.

This involved first disconnecting the cable modem from the net and temporarily connecting it to my computer so that I could once more disable its wireless networking, firewall and NAT functions.

Unfortunately, I now had no internet access at all. What's more, it still refused to work when I subsequently removed the router and went back to just using the modem again. This was really getting frustrating!

Bigpond technical help

At that stage, I decided to check with Bigpond technical help and see if there were any problems with the network. There weren't any as it turned out and I was told that it was probably a modem problem, especially as my Motorola SBG900 was now about 12 years old and is permanently powered on.

As a result, they said that they would send me a new Netgear 4-port cable modem. It would take about a week to arrive, so I would just have to be patient until then.

In the meantime, I left the old modem connected in place, hoping it would come good. And would you believe it? – the next morning, it was working perfectly. I then reinstated the router and once again it all worked perfectly.

But why? Had I really been clever and saved myself around $140 by "fixing" the router? I subsequently checked its four original capacitors but as expected, they all tested OK. So perhaps it was simply a faulty solder joint but I was far from convinced that this really was the problem.

The problem returns

My suspicions proved to be correct. It all worked perfectly for about three weeks and then it got excruciatingly slow again. It then conked out completely a short time later and this time no amount of rebooting either the router or the modem could get it going again.

Once again, I removed the router and just went back to the modem but it still stubbornly refused to work. The modem would connect to the internet OK but I couldn't browse any websites. The modem's error log told me that it was failing to pick up an IP address, so it looked like the fault was in the Motorola modem after all.

By now, I'd received the new Netgear cable modem from Bigpond, so I decided install it and see if that fixed the problem. It's supplied with a preset WiFi broadcast name (SSID) and password but you can easily change those if you wish by connecting it a PC, then logging in and entering in a new SSID and password.

Once its connected to the cable, you then have to log-on to your Bigpond account and register the new modem. It can then take up to an hour for the modem to authenticate itself on the network.

In my case, authentication took just 10 minutes, after which it all worked like a bought one. I again had full high-speed internet access and it's stayed that way. What's more, I now only need to use a single unit rather than use a separate router and modem.

Heat-sensistive fault

My theory now is that the old Motorola modem had developed an intermittent heat-sensitive fault. It first started playing up in early October when Sydney experienced some unusually hot weather. We then had about three weeks of cooler weather, during which time it all worked perfectly, before it again got hot towards the end of October. And that's precisely when the problems reappeared.

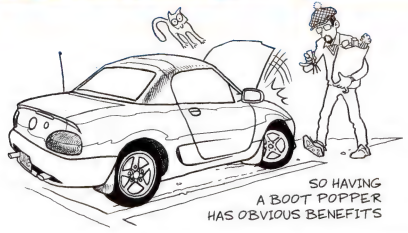
That also explains why it started working again early one morning, when it was cooler, after being left overnight. Maybe changing its electros will do the trick but guess what – I've neither the time nor the inclination!

hold the pack in and after undoing these and disconnecting the plug, I was able to lift the pack clear.

Fishing the broken coil bits out of the ducting was a bit tricky but I eventually got everything out with the aid of an inspection mirror and a pair of long-nosed pliers. As for repairing the coils, several vendors on popular online auction sites as well as specialist parts suppliers offer either genuine replacement coils or equivalent high-wattage resistors. The latter are more popular because the coils will eventually fail again while the resistors should last the lifetime of the vehicle.

The original MG-F coils measured 0.27Ω, 0.75Ω and 1.48Ω. Using combinations of resistors will only approximate some of those values but they are close enough to do the job. In my case, I used two 0.47Ω 10W wirewound ceramic resistors in parallel to make up 0.23Ω at 20W for the lowest setting (position 1 on the dial) and one 0.75Ω 15W ceramic resistor for the second position.

The third coil, which is the heaviest, wasn't broken but it did look somewhat overworked so I replaced



it with a 1.5Ω 15W resistor. Pedants will probably ask why I didn't simply use a 0.27Ω 10W resistor for the first position and the reason is that it would likely burn out, or at least run far too hot. It's generally accepted that 11W is the lowest rating than can be used here and who am I to argue?

The reassembly is a doddle as long as the resistors are carefully kept within the boundaries of the resistor pack and don't stick out too far at the back. Once it was all back together, I'd fixed my car's fan-speed control issues and got rid of an incessant rattle in one fell swoop – an excellent result.

Boot popper

Another useful MG-F modification involves installing a "boot popper" (or remote boot release). I suppose this is useful on any car but on the MG-F it can be a real life saver. That's because the boot has to be opened with the ignition key and this can be a problem if, for example, you've just locked your only key in the boot.

In a mid-engined car like the MG-F, recovering a "locked-in" key from the boot generally involves removing the hood, engine covers and light fittings – not an easy job in a supermarket car park with no tools! So having a boot popper has obvious benefits (provided, of course, you can access the cabin).

Installing a boot popper isn't a particularly difficult job but it does involve running a wire all the way from the boot into the cabin, to wherever you want to install the switch. Boot poppers can be purchased from online auction sites or specialist parts suppliers for about $40 and are easily mounted onto the existing boot release system using the brackets supplied.

As for the wiring, there's an existing wiring loom in the boot lid (for the boot light and various alarm switches) and the new wire can be easily run with this loom. It's just a matter of routing it back through the engine compartment and into the cabin. Once into the cabin, the wire is run along and under the carpets to the boot-release switch. The other side of the popper mechanism, which is based on a solenoid, is simply earthed.

Applying power via the switch activates the solenoid. This in turn pulls on the boot-release cable and opens the boot. Bear in mind that the original idea of using the key is for security. Rag-top cars like the MG-F aren't as secure as hard-tops so things like boot-release switches should be kept out of sight and not labelled to ensure that some ratbag doesn't make use of it if you park somewhere with the top down.

Of course, the alarm will still go off if it's armed and the boot is opened without the key but who notices car alarms these days? It's more likely to annoy people rather than prompt them to call the police.

HP LaserJet 1320N

K. D. of Chermside, Qld recently solved a paper feed problem in his HP laser printer. Here's his story . . .

After printing about 10,000 pages, my HP LaserJet 1320N laser printer developed a problem. For each page printed, a second blank page would also be ejected. The head of the blank page immediately followed the tail of the printed page, without a gap or any of the usual noises of a separate page being fed.

The problem wasn't associated with a particular computer, so I dismissed software and driver issues. The extra sheets were also ejected when printing the internal test pages and weren't included in the firmware's page count. To my mind, this indicated a hardware fault rather than the printer deliberately feeding a second page.

I searched the web but couldn't find a description of exactly the same fault. I did, however, get some pointers and found a very comprehensive service manual. This information led me to three likely suspects: (1) the separation pad in the paper tray, (2) the pick-up roller and (3) the Tray 2 solenoid. These three parts were reasonably priced, so I decided to adopt a shotgun approach and replace them all.

The pad and roller were easily fitted but replacing the solenoid required significant disassembly of the printer's internals. Fortunately, the service manual has clear diagrams which made the job much easier. Once it had all been reassembled, the printer performed perfectly.

So which of the three components had caused the problem? There was some wear on both the separation pad and the roller but I have seen similar ones in far worse condition that still worked well.

The real cause was the Tray 2 solenoid. This solenoid has a small foam pad fitted between the mating metal surfaces to reduce the clicking noise when the solenoid closes. In this case, the foam had decomposed and become sticky, thus preventing the solenoid from opening as quickly as it should. As a result, the pick-up system continued to run for a fraction of a second too long, grabbing a second page in the process.

Had I stripped the printer before I ordered the parts, I could have simply removed the sticky foam and replaced it to repair the solenoid. Still, I now have a working printer and the new parts were inexpensive.

Editor's note: a similar problem with laser printers in general was described in the June 2014 issue.

Teac TV antenna connector

Apparently simple jobs can sometimes take a lot longer than you might think. R. L. of Oatley, NSW found that out the hard way when he took on a broken TV antenna connector . . .

Recently, my next-door neighbour

Using mains cable for low-voltage wiring can be dangerous

Using mains cable for low-voltage DC connections is a very silly thing to do. It can not only create a dangerous situation but can also lead to serious damage if an unsuspecting user or serviceman later connects that lead to a mains supply. J. H. of Bunbury East, WA recently encountered one such situation but luck was on his side. Here's what happened . . .

I own a business which supplies continuous level monitoring instrumentation for industrial applications – mining, waste-water/water, fuel industry etc. In this particular case, I had supplied a system consisting of an ultrasonic level transmitter and transducer which was to be installed in an above-ground diesel storage tank at a power station.

Prior to installation, I had programmed the transmitter for volume (ie, litres). This involved inputting level points and their corresponding volumes at various "breakpoints" ranging from empty to full. The tank manufacturer supplies these breakpoints, about 20 in total, and these will give reasonable accuracy. In all, this programming took about 20 minutes as there are 40 steps to input to the transmitter.

The system was then shipped to the site and was installed by a contractor about four weeks later. However, it didn't all go exactly to plan because I subsequently received a phone call from the site contractor who said that the volume readings were incorrect when compared to a dip-stick. As a result, he returned the unit to me for checking.

The first thing I noticed was that the transmitter had a 1.5-metre mains cable attached. This had open-ended wires with crimped ends, ie, brown, blue, green/yellow.

I tried to terminate this cable to a terminal block but the crimped ends were too large. As a result, I removed the contractor's cable and fitted one of my own cables, connecting it directly to the mains terminals within the transmitter. These mains terminals sit directly below the optional 24V DC terminals.

The problem itself was quite easy to determine – the tank programming figures were incorrect as I had initially been given the tables for a larger tank. As a result, the correct figures were programmed in and the transmitter checked and returned to the contractor.

A few days later the contractor phoned to say that the system wasn't working. His complaint was that there was "no display, nothing at all". I asked what type of power supply had been connected to the transmitter, to which he replied 24V DC!

That's when the penny dropped – I had reconnected his flying lead into the mains terminals because it was a standard 230VAC cable. However, the contractor had originally used the mains cable for 24V DC connections and was now trying to feed 24V DC to the mains input. Once this error had been pointed out, he wired a cable to the 24V DC terminals and the system then began operating correctly.

When I originally received the transmitter, I didn't bother to check the terminal connections because it was supplied with a length of mains cable. By sheer luck, I had been unable to connect this cable to my workshop 240VAC terminal block and I had then removed it without paying attention as to just where it had been terminated. Had the cable fitted, I can't imagine how much damage would have been done to the power supply board if mains power had been applied.

In WA industry, mains cable cannot be used for low-voltage applications and nor can red and black wires as these were part of the old mains cable wiring code. Instead, purple and white leads are generally used for 24V DC connections. The annoying thing here was that the contractor is a licensed installer which does concern me somewhat.

In this case, luck was on my side but next time I will check the terminations, just to make sure.

asked if I could take a look at his Teac 81cm (32-inch) flat-screen TV set. Unfortunately, he had managed to break off the antenna connector when fitting the TV to an adjustable wall mount.

I'd never worked on a flat-screen TV before but really, how hard would it be to replace the connector? And so I said "yes, I'd fix it for him".

He duly brought the TV in and I noticed that he had managed to rip the socket away from the metal support structure. In the process, the centre pin had been pulled out of the socket. My guess is that he hadn't disconnected the antenna cable while he was fitting the set to the bracket and the cable had subsequently caught on something as the set was being moved.

I immediately set about undoing the 20 or so screws holding the back cover in place. Once it had been removed, I saw that the antenna socket was soldered to a shield box that fitted over the input circuit. This meant that I now had to remove the eight board connectors and remove the board from the chassis.

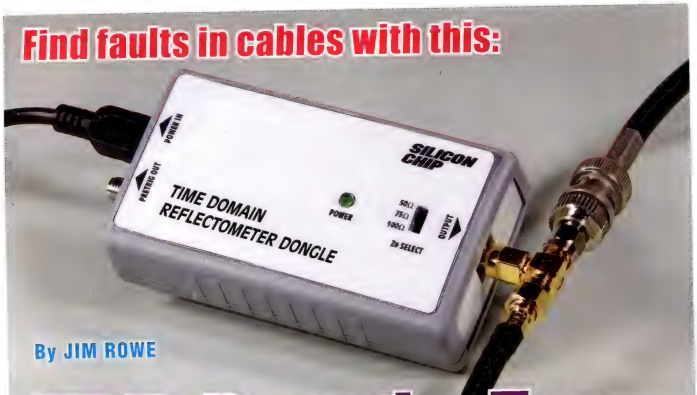
Once it was free, I figured it would be just a matter of removing the shield, replacing the connector and then refitting the assembly back on the board. However, the shield was soldered to the board in eight places and no matter how much I tried to suck all the solder out with my somewhat limited tools, the cover wouldn't budge.

After wasting a lot of time, I considered heating the cover with a large soldering iron so that it would melt all the connecting solder and allow me to remove it. In the end, I decided that would be a bit brutal and instead opted to just remove the centre-pin remains though the vacant socket hole and then try installing a new socket.

I searched though my collection of TV antenna connectors and managed to salvage a similar one from a skirting board fitting. I then soldered a wire to the centre pin and fed it through the vacant socket hole and into its hole in the PCB. Finally, I soldered this wire and the new connector body in place.

As a precaution, I also added a cable tie below the socket to act as a strain relief for the cable and prevent the same problem from reoccurring.

And that was it; I reassembled the TV and it worked perfectly. Unfortunately though, this job had been a lot more involved and had taken far longer than I'd first imagined. SC



By JIM ROWE

TDR Dongle For Oscilloscopes

How would you like to be able to track down faults in coaxial and other cables using time-domain reflectometry or "TDR"? If you have a reasonably fast oscilloscope (20MHz or more), this low cost TDR Dongle will let you do a lot of basic cable fault finding very easily.

THE TIME-DOMAIN reflectometry concepts behind this project were presented in last month's issue in an article entitled "How To Find Faults In Coaxial Cables Using TDR". This was written specifically as an easy to read primer on the subject, so after reading it you should be able to follow this article without problems.

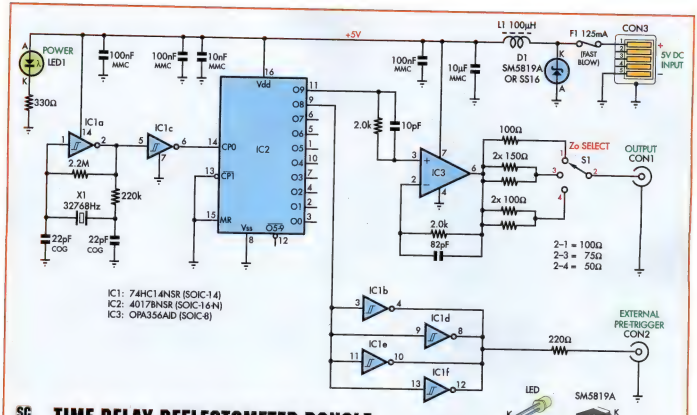
Whether you've read the primer or didn't need to, you should be aware that most TDRs consist of two key components: (1) a voltage step or pulse generator to produce the electrical stimulus which is fed into the cable to be tested and (2) an oscilloscope to look for any reflections or echoes of that stimulus which may be returned by faults or discontinuities in the cable.

If the scope is reasonably fast and also calibrated, this allows you to work out factors like how far along the cable a fault or discontinuity may lie and the kind of fault it is.

High-end commercial TDRs have both of these key components built into the same case, plus some computing power to save you having to convert delay times into cable distances and step amplitudes into impedance levels. But they also carry a fairly stiff price tag, making it hard to justify their cost if you only need to use a TDR occasionally.

But if have a reasonably good scope, you are well on the way to having a usable TDR. So in this article we're describing a voltage step generator capable of being used with almost any reasonably fast scope to produce a "Step TDR".

As shown in the photos, the project is based on a very small PCB with a small number of mainly SMD components mounted on it. This is mounted



TIME DELAY REFLECTOMETER DONGLE

Fig.1: the complete circuit. A 32.768kHz crystal oscillator (IC1a) drives synchronous counter IC2 to produce 30.5µs-wide voltage steps which then pass through op amp buffer stage IC3. Switch S1 then selects one of three source resistances, to suit the impedance of the cable being tested.

in a small ABS instrument case measuring 90 x 50 x 24mm – only a little larger than a USB dongle. And since it can be powered from a USB port of your DSO or PC (or a USB charger), that's why we have called it a TDR Dongle instead of a TDR Adaptor.

Put simply, the TDR Dongle generates repetitive voltage steps which have a duration of 30.5µs (microseconds) at a rate of 3.278kHz – so there are gaps of 274.5µs between them. The 30.5µs duration of the steps is equal to 30,500ns, which allows for viewing reflections in commonly used "solid PE dielectric" coaxial cables more than 3km long.

The TDR Dongle's main output delivers the steps with an amplitude of around 3.5-4V peak, via a choice of three source resistances: 50Ω, 75Ω or 100Ω. This allows it to be used for measurements on most commonly available cables and also means that the effective step amplitude at the input to the cable being tested will be around 1.75-2V peak when the generator's source resistance is correctly matched to the impedance (Zo) of the cable.

In addition to the main step output, there's a second external "Pretrigger" output which provides a falling (negative-going) step output which is 30.5µs ahead of the main output step. The idea of this is that when you're using high sweep speeds to examine reflections relatively close to the step generator end of a cable, it should allow pre-triggering of your scope via its external trigger input, for greater reliability and improved resolution.

How it works

To see how the TDR Dongle works, turn now to the circuit diagram of Fig.1. Only three ICs are involved, plus a handful of other components. IC1 is a 74HC14 hex Schmitt inverter, with one of its six inverters (IC1a) operating as a clock oscillator in conjunction with quartz crystal X1, a tiny SMD device resonating at 32.768kHz. A second inverter, IC1c, is used as an isolating buffer, to maintain a constant load on the output of IC1a.

The buffered 32.768kHz output from IC1c is then fed to the clock input of IC2, a 4017B synchronous Johnson decade counter which counts continuously. As a result, output O9 of IC2 (pin 11) goes high for 30.5µs after every nine clock pulses – during which each of the other outputs (ie, O0 – O8) goes high in turn.

So pin 11 of IC2 switches high every 305µs and remains high for 30.5µs each time. This is how our voltage steps are generated.

These voltage steps from pin 11 of IC2 are fed to the non-inverting input of IC3, an OPA356 high-speed video amplifier being used here as a cable driver. The connection is not made directly but via a paralleled 2.0kΩ resistor and 10pF capacitor combination.

IC3 is connected as a unity gain voltage follower, with the paralleled 2.0kΩ resistor and 82pF capacitor in the negative feedback line being included to achieve high stability, a short rise-time and minimum overshoot. So the output voltage step appears at pin 6 with an amplitude of about 3.5V, limited by IC3's input common mode range of GND to Vcc - 1.5V.

Switch S1 allows selection of one of three possible output series resistances – 50Ω, 75Ω or 100Ω. This allows the source resistance of the step generator

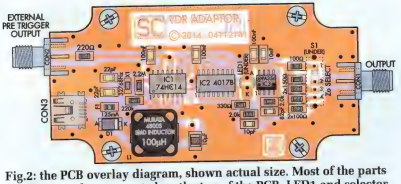


Fig.2: the PCB overlay diagram, shown actual size. Most of the parts are SMDs and are mounted on the top of the PCB. LED1 and selector switch S1 are mounted underneath.

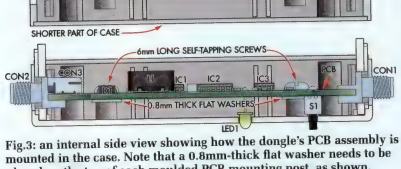
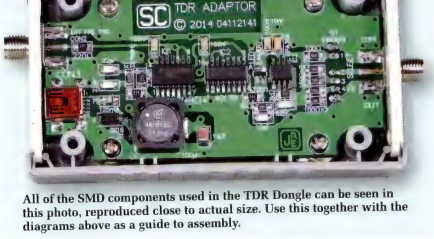


Fig.3: an internal side view showing how the dongle's PCB assembly is mounted in the case. Note that a 0.8mm-thick flat washer needs to be placed on the top of each moulded PCB mounting post, as shown.



All of the SMD components used in the TDR Dongle can be seen in this photo, reproduced close to actual size. Use this together with the diagrams above as a guide to assembly.

to be matched to the characteristic impedance (Zo) of the type of cable you want to test. The output steps pass through the selected resistance to appear at output connector CON1, an SMA socket.

The external pre-trigger output is derived from the O8 output (pin 9) of IC2, which goes high 30.5µs before the O9 output and also remains high for 30.5µs – falling to zero just before each main step.

The remaining inverters inside IC1 are connected in parallel and used as an inverting buffer for the pre-trigger pulses, with their buffered output taken to CON2 via a 220Ω protective series resistor.

So the output pulses from CON2 are negative-going, rising back to zero simultaneously with the rise of each main output step.

The rest of the circuit is straightforward. The 5V DC power needed by the circuit is brought in via CON3, a mini-USB type B socket. Fuse F1 and diode D1 are provided purely for reverse polarity protection, while L1 and the 10µF capacitor are used for filtering the +5V line. And LED1 is used to indicate when the adaptor is powered up and operating.

Construction

As stated, all the parts are mounted on a small PCB coded 04112141 and measuring 81 x 41mm. Fig.2 shows the parts layout diagram.

The only parts which aren't surface-mount devices (SMDs) are switch S1 and LED1. These are both in through-hole packages and are mounted on the underside of the PCB. Note that S1 is actually a sub-miniature slider switch, although we've shown it in the schematic of Fig.1 as a rotary switch for greater clarity.

We suggest that you add the parts to the PCB in the following order, to make it easier:

- Fit power connector CON3, soldering its five tiny connection leads to their matching pads on the PCB before you solder its four "feet" to the larger pads.
- Fit the SMD resistors to the PCB, followed by the capacitors.
- Fit fuse F1, followed by diode D1 which goes alongside it.
- Solder IC1, IC2 and IC3 to the top of the PCB, taking care with their orientation and also making sure that all their pins are soldered to their matching pads. Use solder wick and no-clean flux paste to remove any inadvertent solder bridges between the pins.
- Filter inductor L1 is the last SMD component to add to the board. That's because it's the largest and tends to limit access to some of the smaller components if it's fitted earlier.

Note that L1 is mounted with its two continuous contact strips on the east and west sides (with the PCB orientated as shown in Fig.2), so that they can be soldered to the pads on the top of the PCB.

- Install LED1 and switch S1, the two through-hole parts. These mount under the PCB, with their leads and pins passing up through the matching holes and soldered to the pads on the top of the PCB.

Note that S1 should be pushed up until its underside is hard against the bottom of the PCB, before soldering its pins and its two end mounting lugs to the top copper. By contrast, LED1 is not pushed hard up against the PCB but fitted with the underside of its lens about 3-4mm below the PCB.

This ensures that lens just protrudes through its matching hole in the case after final assembly.

- Fit connectors CON1 and CON2. These are "straight through" SMA sockets which mount on the edge of the PCB at opposite ends. When mounting these, it's a good idea to first solder their centre pins to the matching pads on the top of the PCB, so they are then held in position while you solder their outer earth.

The internal side view diagram of Fig.3 should help in making the above description a little clearer. The PCB assembly should now be complete and can be put aside while you prepare the case.

Preparing the case

There's not a lot of work involved in preparing the case, as shown by the drilling and cutting diagram of Fig.4. There are only five holes in all: two in the deeper part of the case (which becomes the top of the TDR Dongle), two in the lefthand end panel (for access to CON2 and CON3), and the remaining one in the righthand end panel for access to CON1.

There's one point to note before you start on the rectangular holes in the end panels. The end panels are effectively polarised, as shown in Fig.4 – they're tapered between one longer side to the other, which means that they'll only fit into the deeper part of the case one way around (the side with the small central notch in the flange must face upwards, towards the less-deep part of the case).

So make sure you have the end panels orientated correctly before you mark the positions of the holes and (especially) before you begin to drill and cut them out.

This photo shows the TDR dongle being used with a Tekway DST-1102B DSO. It's coupled to the scope's CH1 input via a BNC plug-to-plug adaptor. Because the dongle is very light, this is a good way to use it.

Only one of the five holes is circular – the 3.5mm diameter hole for LED1 in the main part of the case. The others are all rectangular, so you'll need to use a small (1.5-2mm) drill to make a series of holes around the inside of their rectangular outlines first, to allow you to cut away the material inside. Then you can use small jeweller's files to neaten them up and bring them out to their final shape.

Once you have made all of the cut-outs in the case and its end panels, you can make a front panel to attach to the top of the case and to this end we've prepared the small artwork shown as Fig.5. This can be photocopied and covered with clear adhesive tape to protect it from dirt and finger grease, before cutting it to size and then attaching it to the deeper part of the case using double-sided tape or silicone.

Alternatively, you can download the artwork as a PDF file from the SILICON CHIP website and print it out.

Final assembly

Once you have prepared the case, the final assembly is straightforward. The first step is to place the deeper part of the case down on the workbench, with its outer dress front panel underneath. Then place a small flat washer (0.8mm thick, 3.5mm inside diameter) centrally on the top of each of the four moulded-in PCB mounting

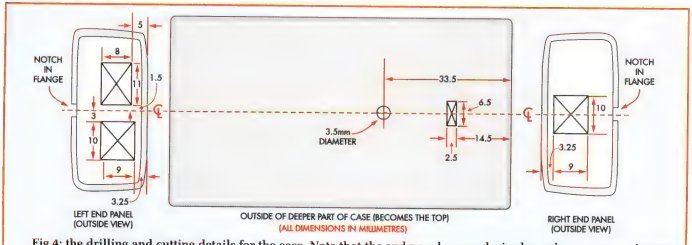


Fig.4: the drilling and cutting details for the case. Note that the end panels are polarised – make sure you orientate them as shown before you make their rectangular cutouts.

Parts List

1 ABS case, 90 x 50 x 24mm (Jaycar HB6031, Altronics H0214)
1 double-sided PCB, code 04112141, 81 x 41mm
2 SMA sockets, edge-mounting (CON1,2), element14 2340518
1 mini USB type B socket, SMD, FCI 10033525-N3212MLF (CON3), element14 2112367
1 100µH 1.6A SMD inductor (L1), Murata 48101SC, element14 2062848
1 mini slider switch, SP3T (S1), C&K OS103011MS8QP1, element14 2319954
1 32768Hz crystal, SMD (X1), element14 2101344
1 125mA fast blow 1206 SMD fuse (F1), Littelfuse 0466.125NR, element14 2144672
4 6G x 6mm self-tapping screws
4 3.5mm ID flat washers, 0.8mm thick

Semiconductors

1 74HC14NSR hex Schmitt-input inverter, SOIC-14 package (IC1)
1 4017BM decade counter, SOIC-16-N package (IC2)
1 OPA356AID video amplifier, SOIC-8 package (IC3)
1 3mm green LED (LED1)
1 60V 1A Schottky diode, DO214AC SMD package (D1) (SS16 or SM5819A)

Capacitors

1 10µF MLCC, SMD 1210, X7R dielectric, 16V rating
3 100nF MLCC, SMD 1206, X7R dielectric, 50V rating
1 10nF MLCC, SMD 1206 X7R dielectric, 16V rating
1 82pF ceramic, SMD 1206, C0G/NP0 dielectric, 50V rating
2 22pF ceramic, SMD 1206, C0G/NP0 dielectric, 50V rating
1 10pF ceramic, SMD 1206, C0G/NP0 dielectric, 50V rating

Resistors (0.25W 1% SMD 1206 pkg)

1 2.2MΩ	1 330Ω	3 100Ω
1 220kΩ	1 220Ω	
2 2.0kΩ	2 150Ω	

posts. These are needed to provide additional spacing.

Next, fit the two end panels over the connectors at each end of the PCB and lower the PCB and end panels together into the deeper part of the case, with the end panels fitting into the moulded slots at each end. Do this carefully, so you don't accidentally knock the spacing washers off their posts. You should find that when the PCB is sitting on the washers, LED1 and S1's actuator will just be protruding through their holes in the front panel underneath – see Fig.3.

After that, it's simply a matter of fitting four small 6G x 6mm self-tapping screws to secure the PCB assembly and then fitting the other part of the case. This case section is also effectively polarised, so you need to fit it the correct way around.

The final step is fitting the four 15mm long countersink-head self tapping screws supplied with the case, to hold everything together. Your TDR Dongle should then be complete and ready for use.

Connecting up

The first step in connecting the TDR Dongle is to provide it with 5V DC power, via a standard USB type A to mini USB type B cable (note that the cable should have a USB-Mini type B plug at the Dongle end, not a USB-Micro plug). The mini plug end mates with CON3 on the Dongle, while the type A plug on the other end will mate with a USB port on your scope, your PC or even a USB charger plugpack.

Now you need to make the connections between the main output of the TDR Dongle, one input of your scope and the input end of the cable you want to test. This is not quite as straightforward because to a large extent, the neatest and most efficient way to make the connections will depend on the connectors being used on the cable to be tested.

The main point to keep in mind is that both the scope input and the input end of the cable to be tested should be connected to the output of the TDR Dongle using the smallest possible number of connectors, "series adaptors" and couplers. That's because connectors, adaptors and couplers always introduce a small discontinuity of their own.

The two sample configurations shown in Fig.6 are intended to guide you in using the TDR Dongle to test cables fitted with two of the most common types of connector. The upper configuration shows the neatest and most efficient approach when you're going to test cables with BNC connectors, while the lower one shows the most efficient approach when the cables to be tested are fitted with SMA connectors.

Note that in both cases we've shown the cable running to the scope input fitted with BNC connectors, because most scope inputs are fitted with BNC connectors anyway.

As you can see, the simplest approach in the "BNC world" is to use an SMA plug-to-BNC socket adaptor right at the TDR Dongle's output, connected directly to a BNC plug-to-2 x BNC sockets T-adaptor. The cable to be tested then attaches to one of the T-adaptor's sockets, while the short cable running to the scope input attaches to the other socket.

On the other hand, when the cable(s) to be tested have SMA connectors, the simplest approach is to connect an SMA plug-to-2 x SMA sockets T-adaptor directly to the Dongle's output socket, as shown in the lower configuration of Fig.6. The cable to be tested is then attached to one of the T-adaptor's sockets, with the scope input cable connecting to the other socket via an SMA plug-to-BNC socket adaptor.

What if you want to test cables fitted with N-type or F-type connectors? In

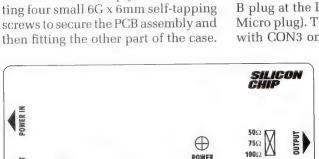


Fig.5: the full-size front-panel artwork for the TDR Dongle, reproduced. It can be photocopied or you can download it in PDF format from the SILICON CHIP website and print it out.

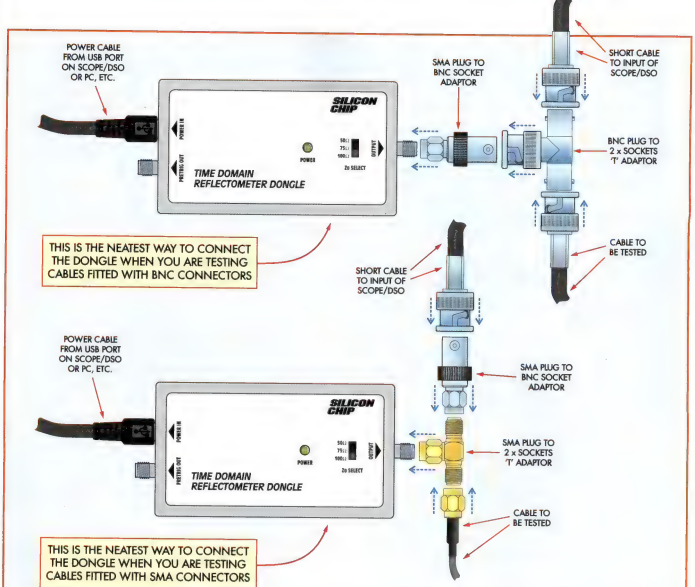


Fig.6: here are two neat and efficient ways to connect the dongle when using it to test cables. A BNC plug-to-plug adaptor can be used instead of the short cable running to the scope/DSO input, to minimise reflections even further.

these cases, the simplest approach is to again use the lower configuration in Fig.6. However, instead of connecting the cable to be tested directly to the lower socket of the SMA T-adaptor, connect it via an SMA-to-N-type or an SMA-to-F-type adaptor.

The same approach will also apply if you need to test cables with old UHF connectors or even Belling-Lee (TV RF) connectors.

What about Ethernet cables?

How could you use the TDR Dongle to check Ethernet or other twisted-pair cables fitted with RJ-45 or similar connectors? To do this you'd probably need to make up a special T-adaptor of your own, perhaps with one or more switches to allow you to select each cable pair to test them. You may also need to build in one or more additional resistors in series with the TDR Dongle's output, to allow better matching to the higher Zo of the cable pairs.

So using the TDR Dongle is likely to call for a range of cable adaptors. Fortunately, many of these are available from the usual suppliers, although you will probably have to order some of the more exotic adaptors from firms like element14. To help you in this regard, here are the element14 order numbers for two of them:

(1) SMA plug-to-BNC socket adaptor, (50Ω): order code 116-9564

(2) SMA plug-to-2 x SMA socket T-adaptor: order code 213-5972

Putting it to use

There's not a great deal involved in using the TDR Dongle for cable testing. The main steps are these:

(1) Connect it up as shown in one of the configurations of Fig.6;

(2) Set S1 on the TDR Dongle (Zo SELECT) to match the characteristic impedance of the cable you want to test;

(3) Power up your scope and set it a timebase speed of around 1µs/division and a vertical sensitivity which gives about 5.0V full deflection.

(4) Set the scope's triggering for a rising edge, at a level of around 1.25V. Alternatively, if you're going to make use of the TDR Dongle's Pretrigger output connected to the scope's external trigger input, set it for a falling edge and a level of around 2.5V.

(5) Apply power to the TDR Dongle and observe the screen of the scope, looking for any reflection steps if there are any to be seen.

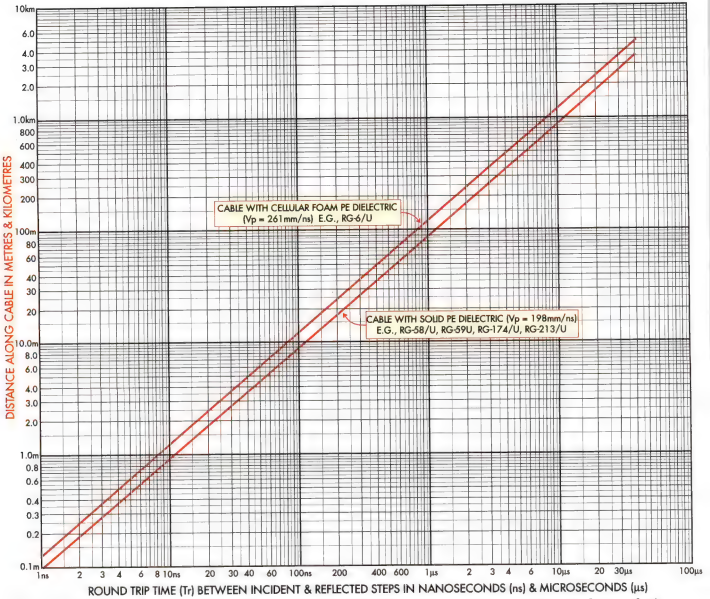


Fig.7: this graph makes it easy to work out the distance of a discontinuity along a cable once you know the round-trip reflection time as displayed on a scope. The lower red line should be used for solid PE dielectric cables (the most common type), while the upper line is for cables using cellular foam PE dielectric.

(6) If any reflection steps are evident, you should then be able to determine what kind of discontinuity they're caused by and by measuring the time between the Dongle's incident step and the reflection step, you should be able to calculate its distance along the cable – knowing the cable's velocity factor.

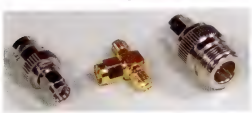
To help you in working out the distance of a discontinuity along the cable from the time difference between the incident and reflected steps without having to turn to your calculator, we have prepared the graph shown in Fig.7. This shows the relationship between inter-step transit time (Tr) and the corresponding distance along the cable, for the two most common types of coaxial cable in current use.

You will also be able to work out the effective impedance of any particular continuity from the relative amplitudes of the incident step Ei and the reflected step Er – together with the polarity of Er, of course. But you're going to have to work this out using the following expression (rearranged from expression 7 given in last month's article):

$$Z_{load} = -Zo \times (Ei + Er) \div (Er - Ei)$$

If your cable has either an open circuit or a short circuit as the discontinuity, this will be very easy to spot. With an open circuit, Er will have the same amplitude as Ei and the same polarity. A short circuit will result in Er again having the same amplitude as Ei but in this case with reversed polarity.

Some test example are shown in the scope screen grabs of Figs.8-11. These were captured using the prototype TDR Dongle hooked up to a Tekway DST1102B DSO.



This photo shows three of the cable adaptors you're likely to need when using the dongle: a 50Ω SMA plug-to-BNC socket adaptor (left); an SMA plug-to-2 x SMA sockets T-adaptor (centre); and an N-type socket-to-SMA plug adaptor (right).

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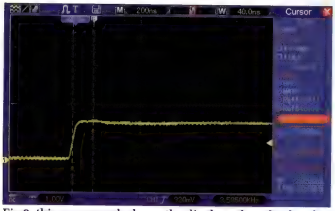

Fig.8: this screen grab shows the display when the dongle was used to check a 4.6m-long SMA-SMA cable correctly terminated at the far end with a 50Ω termination. There are no reflections!

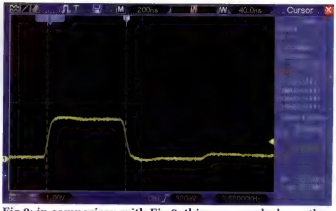

Fig.9: in comparison with Fig.8, this scope grab shows the display when testing an 18m-long SMA-SMA cable with a short circuit at the far end. The step falls back to zero after about 191ns, as you'd expect.

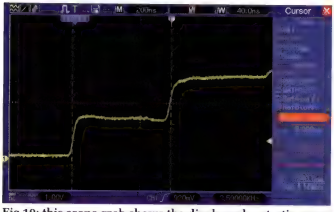

Fig.10: this scope grab shows the display when testing a 22.6m long SMA-SMA cable which was open-circuited at the far end. In this case, the step jumps up to twice its initial value, after about 240ns.

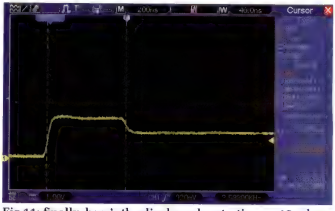

Fig.11: finally, here's the display when testing an 18m long SMA-SMA cable terminated in a 25Ω load instead of the correct 50Ω. As you can see, there's a step down by about 1/3 of the initial value, about 191ns from the start.

We checked three different RG-58/U cables, all fitted with SMA connectors. Fig.8 shows the display with a 4.6m cable, which was correctly terminated in 50Ω at its far end. As you can see, the step continues smoothly way past the 50ns point corresponding to this cable length (indicated by the second vertical cursor), showing that the cable was indeed correctly terminated.

Compare this with the display in Fig.9, which shows an 18m-long cable with a short circuit at the far end. In this case, the step drops back to zero about 192ns from the start and if you check with the chart of Fig.7, you'll see that this time corresponds to a cable length of very close to 18m.

Fig.10 shows the display with a 22.6m-long cable with an open circuit at the far end. Here the step jumps up to twice its initial value, after a reflection time of about 240ns. If checked against Fig.7, you'll see that this corresponds to a cable length of very close to 22.6m.

Finally, Fig.11 shows the display when the 18m cable was deliberately mis-terminated with a 25Ω load at the far end. This causes a step down about 191ns from the start, with an amplitude that's very close to 1/3 that of the incident step. This is close to what you'd expect with a load impedance of Zo/2.

So these screen grabs should give you a good idea of what can be achieved. Happy cable testing! SC

Specification

- A low-cost voltage step generator for use with an oscilloscope to make time-domain reflectometry of coaxial cables.
- The main output provides repetitive voltage steps with a duration of 30.5us, allowing for observation of reflections over cable lengths of up to just over 3km (in common cables with 'solid PE' dielectric). Step rise-time is approximately 26ns.
- Output impedance is selectable between 50Ω, 75Ω or 100Ω, to suit most common coaxial cables.
- A second output provides negative-going steps 30.5us ahead of the main output steps, to allow pre-triggering of the scope via its external trigger input.
- Both outputs are provided via SMA connectors.
- The adaptor is powered from 5V DC, which can be sourced from a USB port on a DSO, a PC or tablet, or a low cost USB charger.
- Current drain is typically 16-20mA. A 3mm green LED provides indication that the generator/adaptor is operating.

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X 2352: 180W x 140H x 105Dmm
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$99 NEW! X 2352 20W
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Great party lights!

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10W 24V DC (115 x 135 x 84mm)	X 2360	$44.95
10W 240V AC (115 x 135 x 84mm)	X 2312	$42.50
20W 12V DC (182 x 158 x 105mm)	X 2316	$59.95
20W 24V DC (182 x 158 x 105mm)	X 2362	$59.95
20W 240V AC (182 x 158 x 105mm)	X 2314	$78.95
50W 24V DC (288 x 238 x 150mm)	X 2365	$179
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True halogen equivalent!
X 2290 36° X 2292 60°
$24.95 NEW! or Cap $19ea

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$29.95 NEW! D 0505
$45.95 NEW! D 0507

$28.50 NEW! A 0309A
Use it at home too!

$44 SAVE 20% M 8627A

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Powertran® 4 x USB Multi Travel Adaptor

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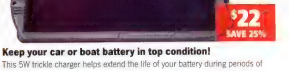

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Huge range of solar, robotics & spring terminal kits in stock for Xmas!

Keep the kids busy building and learning over the summer holidays.

200 in 1 Spring Terminal Electronics Lab Kit

A huge array of fun projects to build for your little 'engineer of tomorrow'. Easy to read and follow instructions - teaches the fundamentals of electronics in a safe and fun way. Requires 6 x AA batteries.

300 fun projects in the one unit!

300 in 1 Spring Terminal Electronics Lab Kit

The 'Rolls-Royce' model with all the bells and whistles. Teaches you about electronics from A to Z. You will learn about electronic parts, how to read schematics, and wiring diagrams. All this, while building up to 300 projects. Provides many hours of tinkering - a great way to gradually build on your knowledge. Requires 6 x AA batteries.

Motorised 4 in 1 Robotics Kit

Assemble 4 different robot designs which teach kids about geared movements in a practical and fun way! Requires 1xAA battery. No soldering required.

A great starter option for the kids

30 in 1 Electronics Lab

Contains everything you need to build a range of electronic projects to encourage learning about essential principles. Requires 2 x AA batteries.

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(SC Dec '13) **Makes a great Xmas tree decoration!** A starter project for kits to learn about electronics. Mimics the musical sounds of a real Bellbird. Includes button cell battery.

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Uses four inbuilt microphones to detect sound (such as a hand clap) and moves toward it. No soldering required. Requires 4 x AAA batteries (not included).

6 in 1 Solar Recycler Kit

Uses common household items like soft drink cans and old CDs to create fun and interesting solar powered designs. Build a robot, steam roller, CD racer, bottle yacht and more! No soldering required.

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Features individual motors for each wheel with clear acrylic base for mounting control and sensor boards. Includes battery holder.

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By Nicholas Vinen

The Currawong Stereo 10W Valve Amplifier, Pt.2

In Pt.1 last month, we described the circuit and presentation of our new Currawong stereo valve amplifier. We now describe the PCB assembly and detail the timber plinth and chassis wiring along with detailed instructions on putting it all together.

MOST OF THE parts for the Currawong are mounted on a single large PCB. This then slides into a slot near the top of a timber plinth, with the remaining components – primarily the two large power transformers – underneath the PCB and attached to the plywood or MDF base.

The front panel carries the headphone socket, volume control, power switch and status LEDs. The input connectors, loudspeaker terminals and power socket are mounted on the rear panel which is recessed into a cut-out in the rear of the plinth.

So let's start putting the main PCB together, which is a significant part of the work involved in building the Currawong.

PCB assembly

Start the PCB assembly with reference to overlay diagram Fig.6. The board is coded 01111141 and measures 272 x 255mm. It's 2mm thick, which makes it more rigid and stronger than typical 1.6mm laminate.

Start by fitting the smaller resistors. The colour-coded stripes on small resistors aren't always distinct so it's best to check each value with a DMM. Use the lead off-cuts to make the two wire links (next to LK4 and LK5).

Follow with the three 1N4007 diodes (D4-D6), in the top corners of the board, with the striped cathode ends towards the right or bottom of the PCB as shown. IC1 can go in next – there's no need for a socket. Check that its pin 1 notch/dot is towards the left side of the board before soldering it.

Then fit all the 1W resistors. Their colour codes are usually clear however it doesn't hurt to measure them to be sure. None of these run hot so they

This view shows the completed PCB assembly for the prototype amplifier, with the front-panel fitted. It's housed in a timber plinth and fitted with Perspex covers to protect the user from high voltages.

can be mounted in contact with the PCB. You may find it difficult to get the specified 9.1kΩ 1W resistors, so 8.2kΩ resistors can be used instead with only a minor impact on performance (don't use 10kΩ as this may prejudice overall stability).

The two large 1N5408 power diodes are next, with both cathode stripes facing the bottom of the board. These will get a little warm so we recommend spacing them about 5mm off the board (eg, using a 5mm-wide strip of cardboard as a temporary spacer). The W04 bridge rectifier can also go in now; again it's a good idea to space it off the board a little.

Next, fit blue LEDs3-6. These have a dual purpose: to indicate the presence of HT and to illuminate the transformers. They also form part of the HT bleeder circuit so must not be left out (if you must omit them, use wire links in their place). Angle each one back so that it will shine on either T3 (LED5, LED6) or T4 (LED3, LED4) and make sure the longer anode leads go through the holes closer to the righthand side of the board.

Now you can mount all the TO-92 package small signal transistors, ie, Q2-Q9. Don't get the three different types mixed up. Follow with the six fuse clips. Check that the fuse retention lugs are on the outside before soldering the clip in place, otherwise you will not be able to fit the fuses. Also make sure that they are pushed all the way down onto the PCB before soldering them in place.

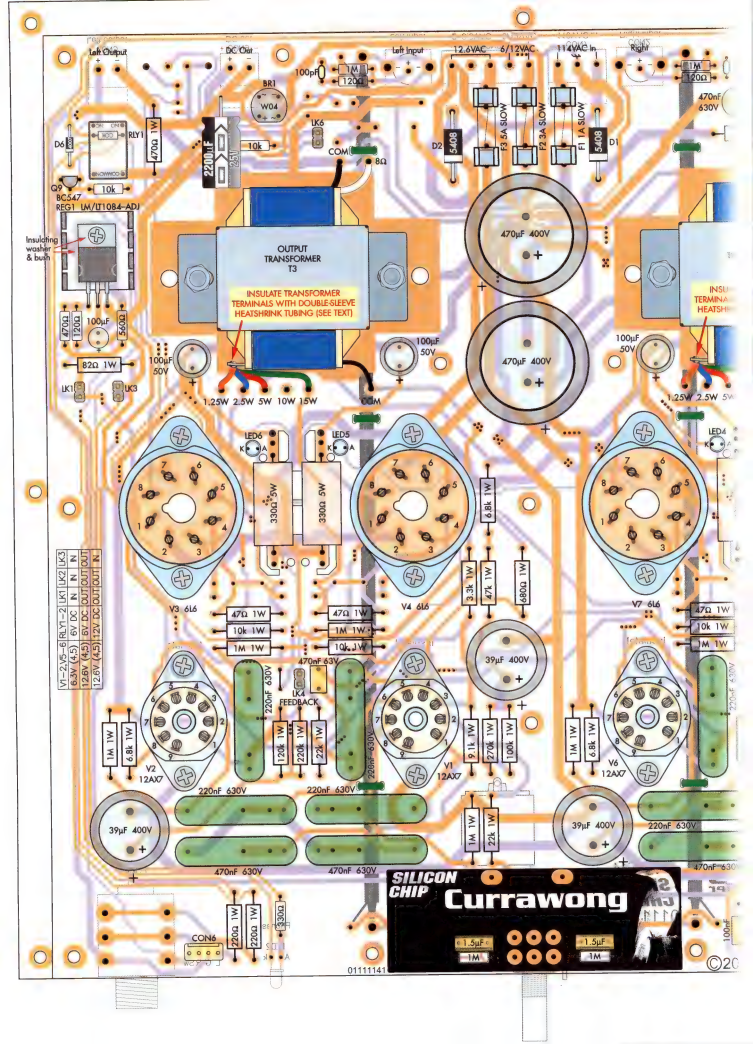
Next on the list are transistor Q1 and linear regulator REG1. These are both fitted with small heatsinks and it's important that the heatsinks are isolated from the device tabs using

WARNING! HIGH VOLTAGES

High AC and DC voltages are present in this circuit. In particular, mains voltages (230VAC) are present on the IEC socket and the primary side of the mains transformers (including the wiring to the power switch). In addition, the transformer secondaries together provide a 114VAC output and the power supply produces an HT voltage in excess of 300V DC which is present on various parts of the amplifier circuit (including the output transformers).

Do not touch any part of the amplifier or power supply circuitry when power is applied otherwise you could get a severe or even fatal electric shock.

The blue LEDs in the circuit indicate when high voltages are present. If they are lit, the power supply and various parts on amplifier board are potentially dangerous. **The completed amplifier must be fitted with Perspex covers as described in Pt.3 next month to ensure safety.**



Left Output
DC Out
Left Input
12.6VAC
6/12VAC
114VAC In
Right
100pF
1M
120Ω
BR1
W04
LK6
COM
8Ω
2200µF
25V
10k
D6
RLY1
470Ω 1W
Q9
BC547
REG1 LM/LT1084-ADJ
Insulating washer & bush
D2
5408
F3 5A SLOW
F2 3A SLOW
F1 1A SLOW
D1
470nF 630V
OUTPUT TRANSFORMER T3
INSULATE TRANSFORMER TERMINALS WITH DOUBLE-SLEEVE HEATSHRINK TUBING (SEE TEXT)
470µF 400V
470µF 400V
470Ω
120Ω
100µF
560Ω
82Ω 1W
LK1
LK3
100µF 50V
1.25W 2.5W 5W 10W 15W
COM
LED6
LED5
LED4
330Ω 5W
330Ω 5W
6.8k 1W
3.3k 1W
47k 1W
680Ω 1W
V3 6L6
V4 6L6
V7 6L6
47Ω 1W
10k 1W
1M 1W
47Ω 1W
1M 1W
10k 1W
47Ω 1W
10k 1W
1M 1W
V1-2,V5-6 RLY1-2 LK1 LK2 LK3
6.3V (4.5) 6V DC IN IN IN
12.6V (4.5) 6V DC OUT OUT OUT
12.6V (4.5) 12V DC OUT OUT IN
470nF 63V
220nF 630V
LK4 FEEDBACK
39µF 400V
1M 1W
6.8k 1W
V2 12AX7
120k 1W
220k 1W
22k 1W
220nF 630V
V1 12AX7
9.1k 1W
270k 1W
100k 1W
1M 1W
6.8k 1W
V6 12AX7
220nF 630V
220nF 630V
39µF 400V
1M 1W
22k 1W
39µF 400V
220nF 630V
470nF 630V
470nF 630V
CON6
220Ω 1W
220Ω 1W
330Ω
SILICON CHIP
Currawong
1.5µF
1M
1.5µF
1M
100nF
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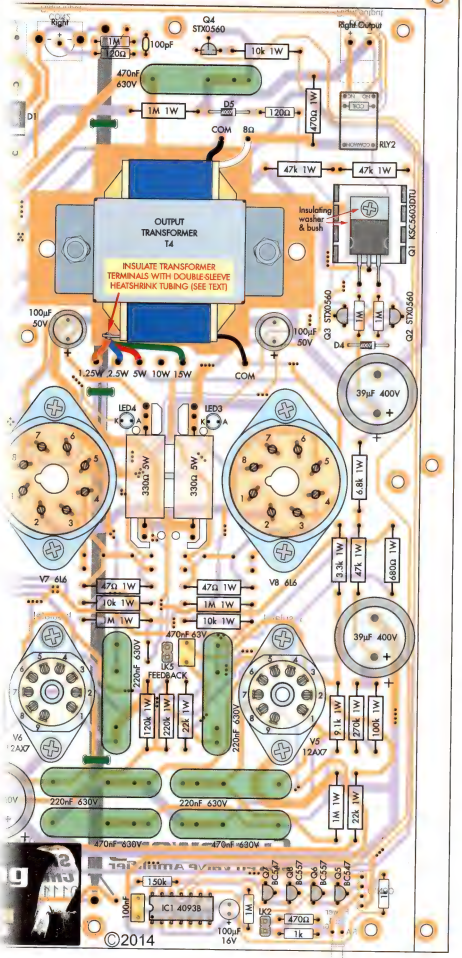


Fig.6: the parts layout on the top of the PCB. This diagram has been split and the righthand side partly duplicated where it meets the magazine gutter, for clarity. The text describes how the valve sockets are mounted; they must be mechanically secured before the pins are soldered. Note that D1, D2 and the 5W resistors should be stood off the board to allow air to circulate around them and don't forget to insulate Q1 & REG1 from their heatsinks.

insulating washers and bushes – see Fig.7. In each case, start by bending the leads of the TO-220 device so they fit through the pads on the board, with the tab hole lined up with the PCB mounting hole.

Note that Q1's centre lead is bent closer to the package than the other two (due to the high voltage between the pins) but this is not the case for REG1.

To mount each device, place an insulating bush in the tab hole, then feed an M3 x 10mm machine screw through from the top. Slip an insulating washer under the device, over the screw thread, then slide the heatsink on from underneath. Drop this assembly onto the PCB, ensuring all pins go through their respective holes, then use a shakeproof washer and M3 nut to hold it in place.

In each case, ensure the heatsink and insulating washer are straight before tightening the nut fully, then solder the leads. That done, fit the two relays, making sure they are nice and flat on the PCB before soldering more than two pins.

Now it is time to install the ceramic capacitors, followed by the MKT (metallised polyester) capacitors, in increasing order of height. Follow with the six pin headers for LK1-LK6. Try to solder these flat on the board and neatly aligned with the edges of the board for best appearance.

You can then bend the leads of the

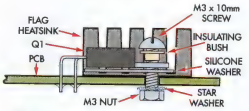


Fig.7: the mounting details for transistor Q1 and regulator REG1. In each case, the device tab must be isolated from the heatsink using a silicone insulating washer and insulating bush.

Parts List

Since publishing Pt.1 last month, we've made a few small changes to the chassis arrangement and this affects the list of parts required. Please note the following changes:

Main board

(1) Delete vertical RCA sockets for CON1 & CON2; add short stereo RCA-RCA lead

(2) 2 x 8.2kΩ 1W resistors can be used instead of the 2 x 9.1kΩ 1W resistors listed

Revised chassis parts

1 timber plinth with base (see text)
1 top cover cut from 3mm clear acrylic (details to come)
1 small tube acrylic glue
1 front panel, code 01111142, 249 x 30mm
1 rear panel, code 01111143, 248 x 53mm
1 160VA 37+37+15+15V toroidal transformer (Altronics MC5337)
1 80VA 12+12V toroidal transformer (Altronics M5112)
4 screw-on 50mm equipment feet (Jaycar HP0832)
1 15mm anodised aluminium knob to suit VR1
1 snap-in fused IEC mains male socket for 1.6mm panels (Altronics P8325)
2 M205 250VAC 1A slow-blow fuses (one spare)
1 red chassis-mount RCA/RCA socket
1 white chassis-mount RCA/RCA socket
2 red binding posts (Jaycar PT0453, Altronics P9252)
2 black binding posts (Jaycar PT0461, Altronics P9254)
1 SPST ultra-mini rocker switch, 250VAC rated (Altronics S3202, Jaycar SK0975)
1 1m length 2-core mains flex
1 1m length 3-core mains flex
1 200mm length 3mm diameter black heatshrink tubing
1 1m length 5mm diameter clear heatshrink tubing
1 200mm length 20mm diameter black heatshrink tubing
1 50mm length 50mm diameter black heatshrink tubing or large insulating boot (Jaycar PM4016)
1 1m length heavy duty red hook-up wire
1 1m length heavy duty black hook-up wire
1 500mm length figure-8 speaker wire
1 12-way screw terminal strip (Jaycar HM3194, Altronics P2135A)
1 M4 x 10mm machine screw
2 M4 nuts and shakeproof washers
2 yellow 5.3mm ID eyelet crimp connectors
2 red 8.4mm ID eyelet crimp connectors
5 red 6.4mm insulated spade crimp connectors
4 solder lugs
1 5mm cable clamp (P-clamp)
12 black 4G x 12mm self-tapping screws
12 4G x 9mm self-tapping screws
1 4G x 6mm self-tapping screw
1 3mm ID flat washer
7 3mm ID spring washers
10 small Nylon cable ties

four 5W resistors to fit through their mounting holes. There are two pairs of holes for each; we used the inner pair but it isn't mandatory. As with the 1N5408 diodes, use a 5mm spacer to stand each resistor off the board. Keep them level and straight for a tidy result.

The 630V polyester capacitors can then be fitted. The PCB is designed with multiple pads for each capacitor, to suit different lead spacings. If you have an odd one, you may need to bend its leads out however most should drop straight in. Refer to Fig.6 to see which type goes where.

Now solder the smaller electrolytic capacitors in place, ie, the six 100µF types. In each case, ensure that the longer (positive) lead goes in the pad closer to the front edge of the board, as shown on Fig.6.

Valve sockets

The valve sockets are secured to the board before soldering, so the solder joints aren't under stress. The specified sockets have solder lugs and the board has been designed with slots to accommodate them.

Start with the smaller 9-pin sockets. Feed M3 x 10mm machine screws through the top mounting holes and tighten Nylon nuts on the underside. Slip two Nylon washers over each screw thread, then pass the screws down through the mounting holes

The 9-pin sockets are secured using M3 x 10mm machine screws, with a Nylon nut & two Nylon washers used as spacers at each mounting point.

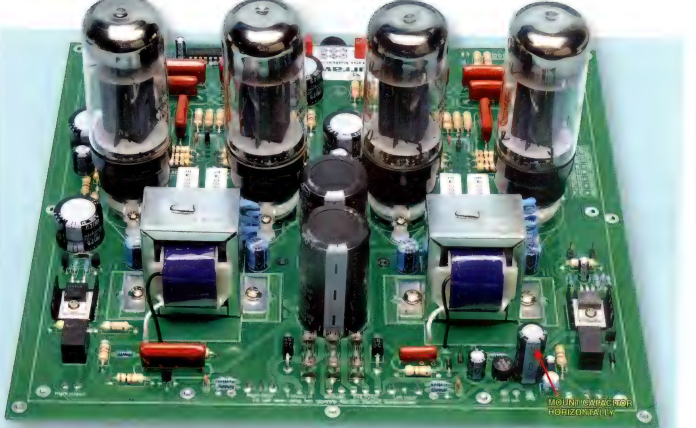
This mock-up shows the final mounting arrangement used for the 8-pin sockets (it differs slightly from that used on the prototype). These sockets are secured using M3 x 15mm screws and M3 x 6.3mm tapped Nylon spacers.

on the board, guiding the solder lugs through the slots. If it won't go in, check that you have the right orientation as it will only fit one way.

You may need to put the solder lugs under a small amount of tension to get them to go through the slots, due to the way they are angled. But once they all line up it should slip into place and you can push the socket right down so it's sitting on the Nylon washers.

Use a shakeproof washer and M3 nut to secure the screw closest to the front (bottom) edge of the board. **Fit a Nylon washer and nut to the other (this is necessary to avoid shorts to adjacent PCB tracks) – see Fig.8.** Do both nuts up tightly, check that the socket is sitting level on the PCB and then solder the pins and repeat for the other three sockets. It isn't necessary to trim the solder lugs after soldering.

For the larger 8-pin sockets, the arrangement is similar but their mounting brackets are supplied separately. Take a bracket and feed M3 x 15mm machine screws through the top of the mounting yokes (see photos), then loosely screw M3 x 6.3mm Nylon tapped spacers on, just tightly enough



Another view of the completed PCB assembly, this time taken from the rear. Check the board carefully after assembly to ensure that all polarised parts are correctly orientated. Note that the 2200µF capacitor indicated by the red arrow must be mounted horizontally (ie, on its side) as shown in Fig.6, not vertically as shown here.

so that the screws stay in place.

Now position this assembly over the PCB and adjust the spacing so that the two screws are equally far from the centre of the mounting bracket and they pass through the appropriate holes on the PCB. You can then remove the bracket and drop the socket in place. Some "jockeying" may be required but it should fit easily once you get all the pins lined up.

These sockets can be installed with eight different orientations but only one is correct. The notch in the central hole must face towards the lefthand side of the PCB. If you solder one incorrectly, it will be difficult, if not impossible to remove (see Fig.6).

With the socket pushed down onto the PCB and orientated correctly, slip the bracket on top and secure it in position with shakeproof washers and M3 nuts. **Note though that for valves V4 and V8, the mounting screw closest to the front (bottom) edge of the board must be secured with a Nylon washer and Nylon nut instead.**

Do both mounting nuts and screws up tightly, then re-check the socket orientation before soldering the eight lugs. Repeat for the other three sockets.

With all the sockets in place, fit the five low-profile 39µF 400V snap-in capacitors, again with their positive terminals towards the front (bottom) of the board. These should be pushed all the way down before soldering.

The 2200µF capacitor can now go in however it must be laid over towards transformer T3 or else the top cover will not fit later. There should be sufficient room for it to sit flat on its side on the PCB. Like the others, it is polarised and the negative stripe should face up.

You can then fit the two large 400V capacitors between T3 and T4. Double-check their orientation before soldering the leads and they too should sit right down on the board; if they aren't perfectly vertical, they may not later fit through their corresponding holes in the top cover.

Output transformers

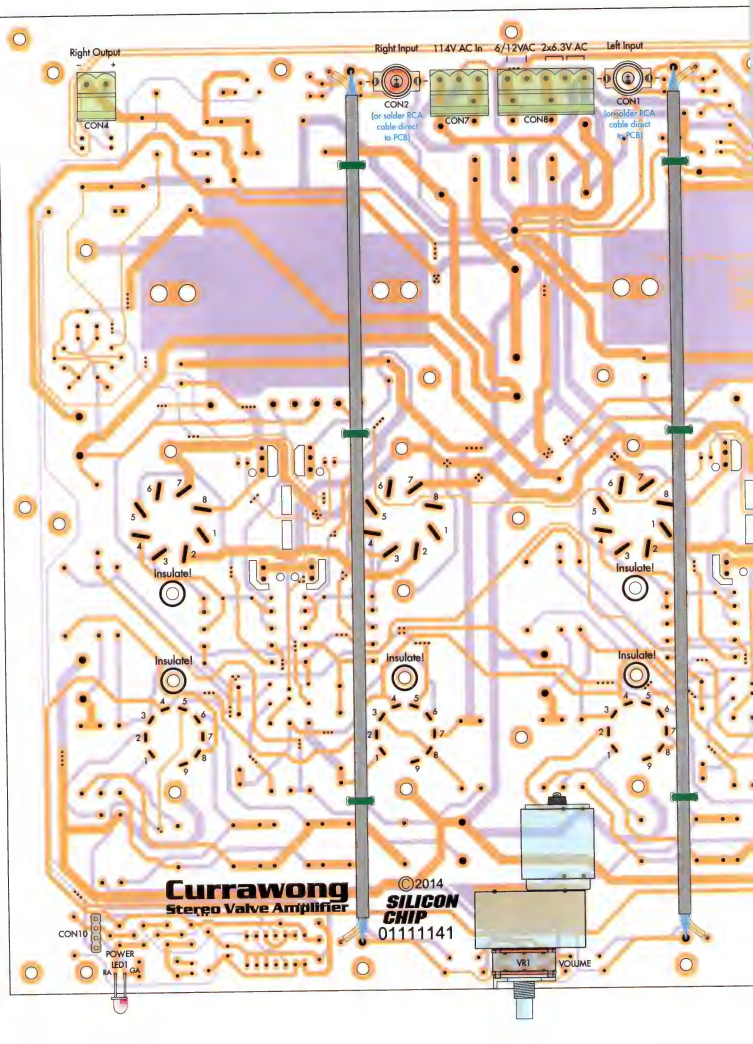
The 15W 100V line transformers (T3 & T4) come fitted with a terminal block on top and stickers indicating the taps. We removed these as we felt it improved the appearance. The stickers can be peeled off and the glue residue gently cleaned off using an appropriate solvent. Methylated spirits or isopropyl alcohol are good choices are they are unlikely to damage the transformer but try not to soak it.

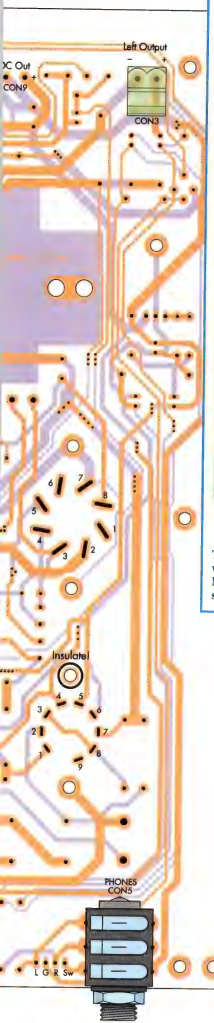
The terminal blocks can be simply pulled off although they're a tight fit and you may need to use pliers. The metal tab used to hold it in place is then bent down.

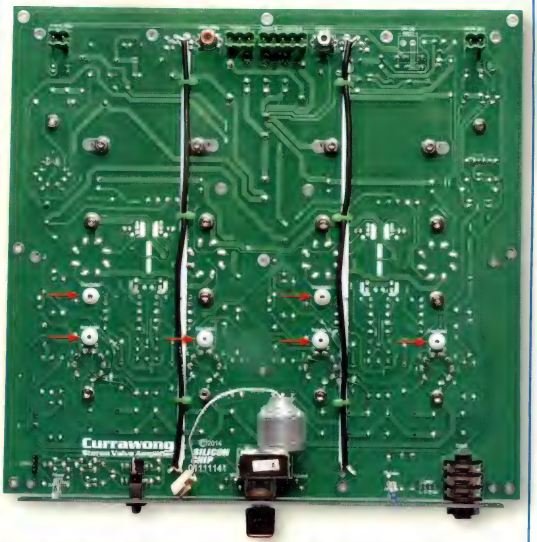
The next job is to cut, solder and insulate four or five wires to the winding tap lugs. The 10W winding is not connected on the PCB so you don't have to wire it up but we did anyway, because we thought it would look better. We used blue wire, to match the blue transformer insulation although different colours are shown on Fig.6 for clarity.

Cut each wire to a length of about 70mm, then strip about 3mm of insulation from one end and 6mm from the other. Feed the longer section of exposed wire through one of the solder lugs and double it over, then solder it in place. Try not to heat the joint more than necessary or add too much solder.

The output transformer terminals all operate at 308V DC and they must all be fully insulated with two layers of heatshrink sleeving to ensure safety. It's just a matter of slipping a 15mm-length of 3mm-diameter blue heatshrink tubing over each terminal


Right Output
CON4
Right Input
CON2
(or solder RCA cable direct to PCB)
114V AC In
CON7
6/12VAC
2x6.3V AC
CON8
Left Input
CON1
(or solder RCA cable direct to PCB)
Insulate!
Insulate!
Insulate!
Insulate!
Insulate!
Insulate!
Currawong
Stereo Valve Amplifier
©2014
SILICON CHIP
01111141
CON10
POWER LED
BA
GA
VR1
VOLUME





This view shows the parts in position on the underside of the PCB. Note the Nylon nuts and washers used to secure the valve sockets at various locations, as indicated by the red arrows. Note also that this is a prototype PCB and the short wire links on two of the 12AX7 valve sockets have been eliminated from the final version shown in Fig.8

and shrinking it down, then adding a second layer. **Make sure each terminal is fully insulated, including the 10W tap, even if you aren't soldering a wire to it. If necessary, use neutral cure silicone to ensure that there is no gap in the insulation where each terminal goes into the transformer.**

Twist the bare strands together at the other end of each wire and tin them in preparation for mounting. Do the same with the three pre-existing wires, after trimming them so that they will reach their PCB pads with a little slack. You can place the transformer temporarily on the board to check this. Don't cut the leads too short.

Once all the wires have been prepared, fit the transformers to the board using M4 x 10mm machine screws, shakeproof washers and nuts. The front side (facing the bottom of the board) should have five or six connections, while the rear of the transformer has two. Make sure they are nice and square with the rear edge of the board, centred on their mounting positions and firmly secured.

It's then just a matter of soldering the eight wires to the PCB. The topmost of the five front wires goes to the leftmost pad, the next one down to the second-from-left and so on.

Fig.8: the parts layout on the underside of the PCB. A motorised pot is shown here for VR1 but a regular 16mm dual-gang log pot can be used instead if you don't want remote volume control. The RA/GA markings for LED1 indicate the position of the red LED anode and green LED anode respectively. Note the orientation of CON3, CON4, CON7 & CON8 and be sure to use Nylon nuts and washers at the indicated "insulate" positions when securing the valve sockets.

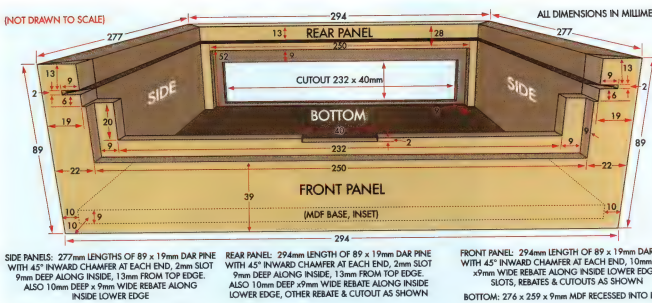


Fig.9: the Currawong plinth details. It's made from four lengths of 89 x 19mm DAR pine arranged in a rectangle with a 9mm MDF or plywood base. The slot cut into the sides and rear accommodates the 2mm-thick PCB while the cut-outs and rebates at the front and rear are for the two panels which the controls and connectors pass through.

Skip the pad labelled "10W" if you only soldered four wires. These can be tack-soldered initially from the top (without melting the wire insulation), then pushed through the board and soldered from the bottom afterwards.

Connect the three remaining wires as shown on Fig.6, then tie the bundles of four or five blue wires together using blue cable ties.

Underside components

The remaining parts are fitted to the other side of the board, as shown on Fig.8. Start with the two shielded cables which run down the middle.

First, cut them to length and remove about 15mm of the outer insulation from either end, then twist the exposed shield braid wires together and strip about 5mm of the inner insulation away. Now twist together and tin these inner conductors and also tin the twisted end of the shield.

Solder the shield wires into the larger of the two holes at either end of the board and the inner wires into the smaller pads – see Fig.8. Make sure there's sufficient solder on the shield braid so that it's rigid and can't move and short to any adjacent pads. Also try to keep the wire reasonably taut along the bottom of the board. Once they've been soldered at each end, fit the six cable ties (three per wire) using the slots provided.

Next, fit the four pluggable terminal blocks. Make sure these go in the right way around, with the curved sections towards the back edge of the board (ie, towards the nearest edge).

The headphone socket can be mounted next and must be pushed all the way down onto the PCB. This can be followed by dual potentiometer VR1, after cutting its shaft to 15mm long. You can cut the potentiometer shaft using a hacksaw and then file off any burrs. If you've opted to have remote volume control, solder the two mounting lugs for the motor in addition to the six for the pot itself.

Now for the two remaining LEDs: blue LED2 goes on the left (with the board right-side up) near the headphone socket while bi-colour LED goes on the right. Use a DMM set on diode test mode to figure out which of the bi-colour LED leads is the red anode – the LED will light red when the red lead from the multimeter is connected to this pin (in our case, the longer of the two leads). This lead goes towards the righthand edge of the board.

Bend the LED's leads at right angles 7mm from its lens and fit the LED so that the lens is centred 10mm below the top of the PCB (ie, 8mm from the bottom). The other LED is fitted in the same manner, with its longer (anode) lead also towards the righthand edge of the PCB.

Input wiring

Note that what the board is designed to accept vertical RCA sockets for the input signals, we decided it was easier to solder a stereo RCA cable directly to the board, which plugs straight into the RCA/RCA sockets on the rear panel. This provides more clearance on the underside of the board for the transformers. So we suggest you get a short stereo RCA lead, chop off a ~500mm length, strip it back and solder it to the left and right input pads, with the shield braid to the terminals marked "-" and the inner conductor to "+".

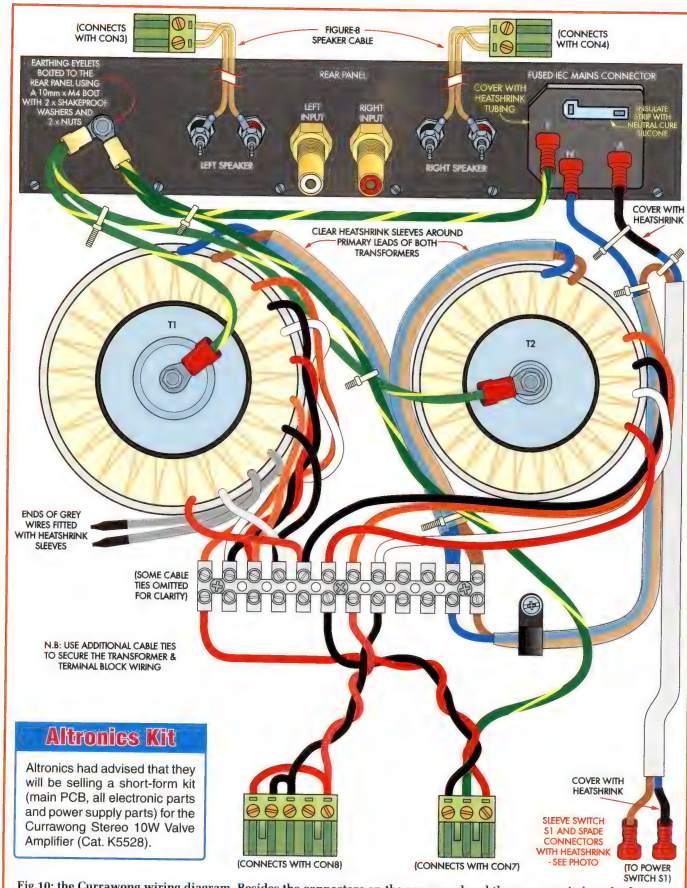
Now fit the three fuses; 1A for F1, 3A for F2 and 5A for F3 (all slow-blow). The main board assembly is now complete.

Building the plinth

The base of the plinth is a sheet of 5-ply or 9mm MDF cut to 276 x 259mm while the rest is made from a single length of 89 x 19mm dressed all-round (DAR) pine, cut to two lengths of 277mm for the sides and two lengths of 294mm for the front and back.

Fig.9 shows the plinth details. A plunge router is required to cut the rebates while a mitre or drop saw is used to make 45° cuts so that the four pieces of DAR pine can be assembled in a similar manner to a picture frame. A drop saw is used to cut the 2mm-wide slots but make sure that all the slots will later line up correctly.

We used wood glue to hold it all together, along with 6G x 20mm wood screws to additionally secure the base.



Altronics Kit

Altronics had advised that they will be selling a short-form kit (main PCB, all electronic parts and power supply parts) for the Currawong Stereo 10W Valve Amplifier (Cat. K5528).

Fig.10: the Currawong wiring diagram. Besides the connectors on the rear panel and the power switch at the front, the only additional components in the case are the two toroidal power transformers (T1 & T2) and the terminal strip which is used to connect their secondaries to the main board. Be sure to pay close attention to the insulation and anchoring of all mains wiring and note that the IEC socket must be covered with heatshrink tubing (see photo).

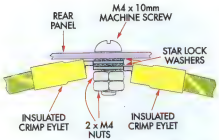


Fig.11: the Earth leads are secured to the rear panel via insulated crimp eyelets as shown here. The second nut serves as a lock-nut, so that the assembly cannot come loose. Make sure that the leads are securely crimped.

Once assembly is complete, check that the PCB will slide all the way back so that the front is flush with the front panel rebate.

After assembly, we smoothed the plinth using sandpaper, stained it with "Jarrah" oil-based stain and finished it with a clear polyurethane lacquer.

Putting it all together

Start by fitting feet to the plinth. These should be placed just inside each corner and attached using 9mm 4GA self-tapping screws. Drill a ~5mm deep 2mm diameter pilot hole for each foot before putting the screw in.

Next, fit the rear panel. This is held in place with a self-tapping screw in each corner and a few extras along the edge, primarily next to the mains input socket. You don't need to put screws through every single mounting hole provided. Again, drill 2mm pilot holes for each screw; due to the limited amount of space, you may need to use a pin vice.

Now fit the connectors to the rear panel. Fig.10 shows how the connectors are fitted. The IEC socket goes in with fuse towards the edge. It will snap into place and should not be able to move much once it's in.

The RCA connectors are supplied with two insulating washers; we kept the one on the inside but didn't bother with the one on the outside as the solder mask on the panel acts as an insulator anyway. Do them up nice and tight; the profile of the mounting holes will stop them from rotating.

Similarly, the binding post mounting holes prevent them from rotating and should result in the wire hole through the metal shaft being aligned vertically. These should also be mounted securely, taking advantage of the supplied spring washers.

It's possible that some binding posts may have their wire hole misaligned even though the shafts are keyed, so check before fitting them. If any are misaligned, you may be able to disassemble the binding post and reassemble it correctly.

By the way, the wire holes on the specified binding posts are quite small. You don't need to use especially thick speaker wire with this amplifier due to the limited output power and low damping factor, but it would be possible to enlarge the mounting holes and fit bigger binding posts if necessary. Alternatively, use banana plugs, which plug into the end of the specified posts.

With the posts in place, prepare the two internal speaker leads. Cut some figure-8 cable to ~200mm lengths, strip about 6mm of insulation from both ends and split the two halves apart slightly at either end. Solder the wires at one end to the smaller eyelets of some solder lugs. Put these wires aside so they can be fitted later.

Power transformers

The transformers should be located as shown in the wiring diagram (Fig.10). Leave enough room between the transformers and rear panel so that you can later reach behind the main PCB as it's being slid in and plug the various connectors into the underside (this requires more clearance than is available above the transformers).

Note that T1 at left is the larger of the two (160VA). We suggest a gap of no less than 50mm between T1 and the rear of the case. In practice, this means positioning the transformer mounting bolts so that they are approximately 115mm from the back edge of the plinth (ie, about 96mm from the inside rear edge).

Mount the transformers using the supplied plastic mounting washers, metal plates and washers via 6mm holes drilled in the bottom of the plinth but do the nuts up loosely at this stage. Note that these mounting holes are the only ones drilled right through the base; all other screws used are self-tappers which don't penetrate fully.

Now position the terminal block, as shown in Fig.10. Use three 12mm self-tapping screws to hold it in place, one in the middle and one at each end. Again, it's a good idea to drill 2mm pilot holes first.

For each pair of transformer primary wires (ie, blue and brown), cut a length of 5mm diameter clear heatshrink tubing to cover the entire length except for about 10mm at the end. Adjust the wires so that they run parallel and so that they end side-by-side, then shrink the tubing down. Bend the wires so they run as shown on the wiring diagram and terminate them in the terminal block. Once they're firmly screwed in placed, fit a cable tie around the lot.

The two grey wires from T1 aren't needed, so bend the bare ends over in a U-shape and then insulate with some 5mm diameter heatshrink tubing. Now, twist the six sets of transformer secondary wires together (red/black and white/orange). This will help to minimise the hum and buzz fields radiated by keeping the magnetic loops small. You can twist the grey wires in with their associated secondaries as we did, or leave them separate.

Now it's just a matter of bending the bundles of secondary wires down to reach the terminal block and screwing them in as shown in Fig.10. Be careful when doing the terminals up, since the solid copper wires are quite thin and are loose within their insulating sleeves. This makes it easy to think you've secured it in the terminal block when you haven't so tug gently on each one to make sure it won't come loose.

Now make up two pairs of twisted red/black heavy-duty wires around 200mm in length and attach them to the near side of the terminal block, as shown in the wiring diagram. Screw the other ends into the plug portions of the pluggable terminal blocks as shown. Note the two extra short wires required for the 5-way plug; fit these now too.

Once all the wires are in place, measure the resistance between the red/black pairs in the two terminal block plugs (for CON7 & CON8). You should get a low reading (<10Ω). Any higher than that suggests at least one wire is not making good contact in the terminal block, so go over them again.

Earth wiring

Before making any connections to the IEC socket, it's a good idea to cover the exposed metal strip as this operates at 230VAC. We also shrunk a length of 50mm-diameter heatshrink tubing around the rear of the connector (Jaycar Cat. WH5582) – see photo.

Two Earth wires are required. Start

This is the view inside the plinth with all the wiring completed. Be sure to cover the IEC socket with heatshrink tubing as shown.

by stripping the yellow/green striped wire out of a length of mains flex, then remove the insulation from one end and crimp securely into a 6.4mm insulated female spade connector. Plug this into the IEC mains input socket and route the wire to the rear panel Earth lug hole at the lefthand side.

Note that if you are using a plastic boot to insulate the mains socket, you will have to feed the Earth wire through that before plugging it in.

Cut the wire so that it reaches 150-200mm beyond this Earth lug hole, then mark the point where it passes that hole. Using sharp side-cutters, carefully remove about 25mm of insulation at the marked point without damaging the copper conductors. This can be done by making a series of nicks around the wire at either end of the 25mm section, to separate that piece of insulation from the rest, then slitting down the isolated section and peeling it away.

Double over the exposed copper wire, squeeze it together using pliers and then crimp it into one of the yellow 5mm inside diameter eyelet connectors. Bare the copper at the far end of the wire; this goes into the centre terminal of the 3-way pluggable terminal block.

Now for the second Earth wire. This needs to reach from the top of one transformer mounting bolt, to the rear panel Earth point and then to the other transformer mounting bolt. Cut it to length, mark the location of the rear Earth panel point, strip the insulation at each end and crimp an 8mm inside diameter red eyelet connector at either end. Strip away the insulation in the middle as before and crimp it into the other yellow eyelet.

Now attach both yellow eyelets to the rear panel Earth point as shown in Fig.11. To do this, feed an M4 x 10mm machine screw in from the rear and place a shakeproof washer over the thread, followed by the eyelet connector from the IEC socket, then another shakeproof washer, then the second eyelet and an M4 nut. Do this nut up tight, then do up another nut on top, so it can't possibly shake loose.

You can now remove the transformer mounting bolt nuts one at a time and fit the red eyelet connectors under the flat washers. When refitting the nuts, do them up firmly but not so tight as to risk crushing the transformer windings.

Switch wiring

Prepare the power switch by cutting a length of 2-core figure-8 mains flex to around 500mm, then strip away the outer insulation for about 200mm, exposing the blue and brown wires. Cut the blue wire short, to 40mm, then strip the end and cover it with 3mm-diameter black heatshrink tubing back to the sheath. Crimp on a 6.4mm red insulated spade connector.

Cut the brown wire to the required length as shown in Fig.10 and strip the

The rear panel carries the IEC socket, the speaker terminals, the audio input sockets and the earth screw. Do not operate the unit without the Perspex covers in place (see Pt.3 next month).

insulation at the end. Run this though a section of clear heatshrink along with the blue wire you cut off earlier and crimp a 6.4mm insulated red spade lug on the IEC socket end of the blue wire, as shown in the wiring diagram.

Now plug the two spade connectors into the rear of the IEC socket (blue wire to Neutral, heatshrink-covered wire to Active). If using a boot, feed them through first. Lay the cable along the bottom of the case and screw it into the terminal strip as shown. Fit the P-clamp in the position indicated using a 6mm self-tapping screw and washer after drilling a small pilot hole.

Preparing the front panel

If you're going to fit the optional remote volume control, you will need to drill a hole in the front panel for the IR receiver. This should be vertically aligned with the power indicator LED (at right) and 28mm to the left. Drill the hole to at least 5mm.

Note that if using a SILICON CHIP front panel, there may be a hole position indicated on the rear but this may not be correct as we changed it while building our prototype.

The mains switch can now be fitted. It should click into place but make sure it has the correct orientation, so that it's switched down to connect the two terminals. If you switch doesn't have an "on" marking on the front, use a multimeter to check which way around it should go.

Now strip the sheath at the loose end of the mains twin flex back by about 30mm, strip the insulation from the two inner wires and crimp the two remaining 6.4mm insulated spade connectors onto these.

Slip a couple of lengths of 20mm diameter black heatshrink tubing over this cable and then plug the two spade connectors onto the power switch lugs securely. That done, slide one length of the heatshrink tubing right over the rear of the switch body and shrink it down, then slip the other length on top and shrink that too.

The rear of this switch must be thoroughly insulated (as explained above) since it is connected to mains Active and is near the front panel controls and other circuitry.

Now fit the two speaker wires prepared earlier to the binding posts. This is simply done by securing the solder lugs between the two supplied nuts on each binding post shaft. Do this with the correct polarity as shown in Fig.10.

You can finish all the wiring by fitting some cable ties. In addition to the one fitted to the transformer secondary wires earlier, use several others to tie the transformer secondary wires in bundles close to the terminal block so that none of them can come adrift. Also fit some cable ties to the mains and Earth wiring to hold it in place.

Checking the wiring

Removing the board after it's fitted is a bit fiddly so it's best to do as much checking as we can now. First, use a DMM set in Ohms mode to measure the resistance between the Earth pin on the IEC socket and each of the Active and Neutral pins. There should be no continuity at all (the meter should show "OL" or similar).

Check also that there is no connection between any of the secondary winding connection points on the terminal block and any of the Earth, Neutral or Active pins on the IEC socket. Then take a quick look over the wiring and make sure nothing is touching or shorting to anything it shouldn't be.

Move all the loose wiring (terminal plugs, etc) out of the way, then plug in an IEC mains lead. Check that the power switch insulation is intact, then plug in and switch on. Check the AC voltage across each pair of red and

You Must Use A Ratchet-Driven Crimping Tool

One essential item that's required to build this amplifier is a ratchet-driven crimping tool, necessary for crimping the fully-insulated quick-connect terminals to the leads.

Suitable crimping tools include the Altronics Cat. T1552, and the Jaycar TH1829. These all feature double-jaws so that the bared wire end and the lead insulation are crimped in a single action.

Don't even think of using one of the cheap (non-ratchet) crimpers that are typically supplied in automotive crimp kits. They are not up to the job for a project like this, as the amount of pressure that's applied to the crimp connectors will vary all over the place. This will result in unreliable and unsafe connections, especially at the mains switch and IEC socket terminals.

By contrast, a ratchet-driven crimping tool applies a preset amount of pressure to ensure consistent, reliable connections.

black wires connected to the terminal block plugs.

Use caution when doing this as the transformer secondaries can put out over 120VAC – don't touch the plugs while the power is on! It's easier to probe the terminal block where the red and black wires are terminated.

You should get close to 13VAC across the right-most output pair (going to the 5-way plug). Now, if the transformer phasing is correct, the other pair (going to the 3-way terminal) will read over 110VAC; possibly over 120VAC with no load. If you get a reading closer to 90VAC then you will need to switch off and swap around the black and red wires from the 80VA toroid. Power it back up and check that the voltage is now correct.

If either reading is much lower than specified, there is probably a bad connection to the terminal block, so you will have to switch off and re-check all the connections. But assuming the voltages are OK, remove the IEC mains cord and proceed to final assembly.

Mounting the board

If you're fitting the remote volume control add-on (to be described next month), make sure that the remote board is attached to the main board and that the motor is plugged in. Then slide the board into the case carefully and slowly, checking that the connectors on the underside don't catch on any wires. Push it back about two-thirds of the way, with the attached RCA leads folded over the top, then plug them into the internal RCA sockets on the rear panel and push them all the way home.

It's a good idea now to check that there is good continuity between the inner and outer contacts of the rear panel RCA sockets and the input wire solder termination points on the top of the PCB. They should all read low resistance.

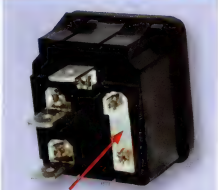
Now for the tricky bit. It's necessary to plug the four terminal blocks into the underside of the board but you have to slide it almost all the way back for there to be enough clearance underneath to do so. Thus, you need to reach around the back edge of the board and push them up into place. And watch out because unfortunately, these pluggable connectors are open on the sides so it's possible to plug them in offset from the correct position!

Start with the 3-way and 5-way connectors in the middle of the board as these will have the best clearance and you won't have to push the board back as far to plug them in. Note that the screw housing projection of each plug faces the front of the case.

Once they're in, you can check that the 3-way connector is fitted correctly by confirming good continuity between one of the valve socket mounting screws and the IEC socket Earth pin. Similarly, the 5-way connector is plugged in correctly when there is a very low resistance between the pins at either end, which you can probe on the top of the board.

The procedure for the two speaker terminal plugs is the same but you will probably have to push the board back even further to make room for them to fit. Check for good continuity between each "+" speaker output pin on the top of the board and the red binding post.

Assuming that's all OK, push the PCB all the way back. You may find it hesitates when it reaches the rear panel



This metal strip on the IEC socket operates at 230VAC and should be insulated using silicone sealant.

but you should be able to "finagle" it in. Recheck the isolation between the Earth and Active/Neutral pins on the mains socket, and the Active/Neutral pins and the eight supply pads on the main board (ie, immediately behind the fuses), just to make sure that pushing the board in hasn't disturbed any of the wiring.

Now place the front panel over the pot shaft and gently push it back, guiding the two LEDs through their respective holes. Loosely fit the pot and headphone socket nuts, then you can drill 2mm pilot holes for the two lower mounting holes in the corners of the panel and attach it using two black self-tapping screws. Finish off by tightening the two nuts and attaching the knob.

That's all we have space for in this article. **Next month we'll go over powering it up and checking it out. Then we'll fit the clear top cover, to make the whole thing safe to operate.** We'll also describe the optional remote control add-on board. SC

No licence fees. . . no call fees . . . up to 100 individual users (or more) . . . no approvals needed . . . completely private and encrypted conversations . . . anyone can call anyone (or everyone!) . . . small, rugged, waterproof handheld sets . . . easy to set up, maintain and use. OK, what's the catch?

ICOM's new "IP" Two-Way Radios

Review by Ross Tester

At around 60 x 26 x 110mm (plus whip antenna, if fitted) and weighing just 200g, they're a lot smaller than most of the two-way radios you've used in the past. But don't let the size fool you! Inset top right is the radio without the whip antenna – it's obviously shorter but the range will be somewhat reduced.

Let's imagine you're starting a business which needs reliable internal communication between staff.

Hmm. . . Mobile phones? Too restrictive (one conversation at a time), virtually uncontrollable – and could be very costly (where's the storeman's cousin Bob? Baghdad?).

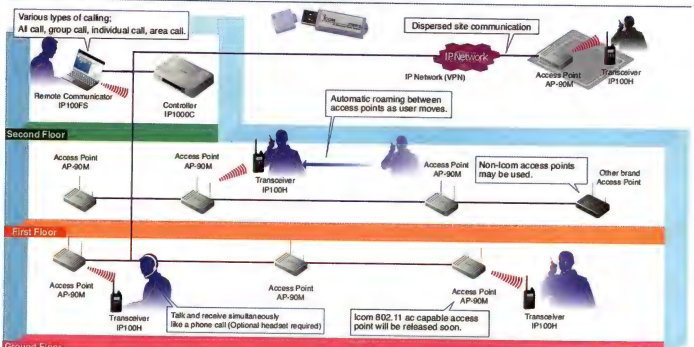
You could go the very cheap route and use CB radios (lots do!). If you can find a clear channel (and it's a big if, particularly in cities) and if you can stand any amount of interruption, interference and even malicious meddling, that might be an option.

Many construction companies, for example, use CBs to communicate on site, though we shudder to think what might happen if someone nearby thought it funny to tell a crane driver to drop or move a load while workers were underneath . . .

Or you could elect to go the totally secure route and get two-way radios on your own licenced frequencies.

That's not easy to do these days, with the bands so crowded, and it will cost you a significant amount of money. It's more than likely you will need to share your channels with another user, hopefully far enough away as to not cause you interference.

IP ADVANCED RADIO SYSTEM IP100H • IP100FS • IP1000C



This simplified diagram shows a typical setup. Many users can communicate simultaneously, even in full duplex (à la a telephone) if an optional headset is connected to the IP100H radio and users can roam from access point to access point. The IP100FS shown above is the software which drives the system – it's supplied on a USB flash drive.

But at least you won't have to put up with the "smartalecs" which seem to be legion on the CB frequencies.

Nor would you have to worry that anyone within range could eavesdrop on your (perhaps sensitive) company communications. It happens with CB!

There are organisations, by the way, who specialise in providing licenced two-way radios, using their own dedicated frequencies, on either short-term or long-term basis. But again, it'll cost you!

Now there's another option: IP radios

Recently introduced by world communications leader ICOM, the IP100 Advanced Radio System changes the way you'll think about two-way radio. They're neither traditional radio nor CB, even though their handsets look and operate (as far as the user is concerned) quite similarly to both.

IP radios (IP stands for Internet Protocol) offer the best of both worlds, having been described as "bridging the gap" between the two.

They're digital, not analog, with all the benefits that technology brings. But that's not the major benefit.

Instead of using power to transmit long distances, they are designed to operate over the type of distances you're used to with WiFi-equipped tablets, phones etc.

Most traditional handheld two-way radios operate with around 1-5W output. The output power of the IP100 is the same as your other WiFi devices, less than 10mW.

Indeed, IP radios operate via WiFi and your computer network, using either existing or purpose-installed WiFi Access Point(s) – the radio operates within the same 2.4GHz WiFi band, using the same 802.11a/b/g/n standard. It can also operate on the 5GHz WiFi band.

Just as the WiFi equipment you currently use does not need to be individually licenced (like your other WiFi devices, it's covered by a "class" licence), there's no annual fee to pay.

As with WiFi, IP radio range is somewhat limited – usually reckoned at 50-100 metres – but you can easily increase this by either using a WiFi range extender or by adding more access points.

For example, by putting an access point (or multiple access points) on each floor of a multi-storey building, you could talk anywhere within the building.

Or perhaps you have a shopping centre, a college or university campus, a freight terminal, even an office and warehouse . . . you name it! You can expand the system out as far as you wish to ensure 100% reliable communications.

With appropriate expansion equipment, the IP radio system can also link into other gear such as other radios, phones, an IP phone system and even multi-site trunked radios to give you both within-site and out-of-site coverage.

The IP100H has an internal antenna which is fine in an ideal signal location but limits range if it is less than ideal. For maximum range, you can screw in the 80mm-long mini-whip antenna (supplied) to its SMA connector.

Sound quality

Communication over a wireless LAN offers wider frequency bandwidth than does a traditional two-way radio communication system; therefore, the sound quality of the IP100 system is higher – in fact, it's comparable to that of a mobile phone.

This often overlooked "feature" (or lack of it!) in analog two-way radio systems can mean the difference between their often difficult-to-decipher transmissions and the much easier-

to-understand messages of a digital system.

What you need

In its simplest form, all you need to set up the system is a couple of IP100H handsets (as photographed opposite), a WiFi access point and an IP1000C controller.

The IP1000C connects to a PC via Cat5E cable, while the access point similarly connects to the controller.

The IP100H handsets are connected to the WiFi network by giving them a name (eg, Security 1) then assigning IP addresses just as you would for any other piece of WiFi hardware.

ICOM recommends that the first time you set the system up, it be done on a stand-alone computer system.

It's quite possible (maybe even probable) that the IP addresses used by the IP1000 system will have some conflicts with your existing network and you don't want to bring the network down while troubleshooting!

Having said that, it is perfectly acceptable to use it with existing access points: once it is operational in stand-alone mode (it's good learning for you!), you can then transfer it to your building WiFi network and resolve any conflicts that occur.

Of course, if you do have a computer network/WiFi specialist available, so much the better.

Setting it up

You really don't need a high level of computer skills to install the IP1000 system, just a basic understanding of wireless networks, access points and IP addresses.

(If you don't have these skills, ICOM have a comprehensive step-by-step instruction manual available for downloading).

You'll need a PC running Windows 7, 8 or Vista, an 802.11a/g access point, Cat5E cables, the IP1000C controller, IP100FS software and as many IP100H handheld transceivers as required (minimum 2).

The various addresses, SSID, authentication and so on are set and the IP100H handhelds are registered, and that's just about all there is to it.

Now one handheld can talk to the other in the normal "radio" way – push to talk and release to listen. Add a headset and it can all be done duplex.

A multiple handset installation would normally use the IP1000C

The IP1000C controller, which is the "heart" of the ICOM system and connects to a PC via Cat5 cable. It keeps track of all the radios on the network (up to 20 or up to 100). Up to 11 IP1000Cs can be interconnected for HUGE radio networks (ie, up to 1100 stations).

controller. By setting up user IDs handhelds can call specific units or the controller can call specific individuals, groups, or all units.

You can even send messages, similar to text messages on a mobile phone, to the same.

There's enormous flexibility built into the system for advanced users – far more than we could review here.

Other benefits

- Because each IP100H radio logs onto its closest access point, the controller (running the IP100FS software) can roughly see where each transceiver – and therefore its user – is situated. "Hmm. I thought XYZ was supposed to be in purchasing, not lazing around in the lunchroom . . .!"
- If your networks have been connected as VPNs (with their own access points), communication between separate locations is entirely feasible.
- If there is a software or other maintenance upgrade, most happen wirelessly (and without user intervention) over the network.
- The same wireless security protocols as used in your WiFi network (WEP (64/128bit), WPA-PSK and WPA-PSK2) encrypts the calls to and from the handsets.
- Up to 27 hours operation is possible with the standard Lithium-Ion battery supplied.
- Standard size systems are either 20 or 100 users. But if you have need for an either bigger system, you can interconnect up to 11 IP1000C controllers, giving you massive expansion.
- Hands-free operation is possible with an optional headset (this also gives full duplex communication).
- You can set the system up with individuals or with groups sharing a common channel.
- The system is not limited to speech – it will also handle SMS (text) messaging where required.
- High security is built into the system. In the event of a lost or stolen unit, it can be remotely "killed", "stunned" and even "revived".
- In an emergency, the IP100FS can command the IP100H transceiver to transmit whatever its microphone can pick up (without the user doing anything).
- A "mixing" function receives multiple transmissions at once; one-to-many transmissions are also catered for.
- A vibrate alert warns you of incoming voice or text messages.
- IPX7 waterproof (1m immersion for 30 minutes) so it's ideal for less-than-ideal locations.

Where from, how much:

The IP100 Wireless LAN Radio System is available through authorised ICOM Australia dealers (see www.icom-australia.com/dealerlist.html).

Included with each transceiver are a battery, belt clip and whip antenna. A range of options is available, including higher capacity batteries, headsets, desk microphones, speaker microphones, rapid and multi-chargers and cables (if required).

Recommended retail prices (all including GST) for the various components are:

IP100H Transceiver:	$539 (each)
IP100FS PC Software:	$1320
IP1000C Controller: (20 user)	$1650
IP1000C Controller: (100 user)	$6050

ICOM (Australia) Pty Ltd are at Unit 1, 103 Garden Rd, Clayton, Vic 3168. Tel (03) 9549 7500 sc

PRODUCT SHOWCASE

Damaged or broken thread? Fix it!

Hare & Forbes Machineryhouse stock a range of thread repair kits starting from $27.50 and offer different thread sizes. These kits come complete with a HSS drill bit, HSS thread tap, stainless steel thread insert and installation tools. Although it's not difficult to install, you do need a little care when attempting this type of repair and if it's your first time doing so, simply practise on something else to get familiarised.

Call into your nearest Hare & Forbes Machineryhouse store or log onto www.machineryhouse.com.au, sign up to become a Machineryhouse mate to place order and have them shipped direct to you.

Contact:
Hare & Forbes Machineryhouse
1/ 2 Windsor Rd Northmead NSW 2152
Tel: (02) 9890 9111
Website: www.machineryhouse.com.au

WIN A R&S DSO – IF YOU'RE QUICK!

Did you see the Rohde & Schwarz advert in November SILICON CHIP? (p5)? If not, you *almost missed* the chance to WIN one of two R&S HMO1002 Digital Oscilloscopes!

Entries close on December 8th, so you'll have to hurry... Simply log onto www.customer.rohde-schwarz.com/live/rs/internet/campaigns/enter_to_win/ for all the details.

Vandal-proof outside touch screens

With the proliferation of walnut-sized brains around these days, kiosk and outside display developers will be interested in a series of open-frame touch screen displays that are claimed to be vandal and impact-proof.

From UK-company Display Solutions, the capacitive touchscreens have an optically bonded layer of glass secured over the PCAP touch sensor. The edge-to-edge flush design enables easy cleaning and is well suited to outdoor environments.

The screens are available from 15 to 19-inch and are Windows 7 compatible.

Contact:
Display Touch Solutions
1 Osprey Ct, Huntingdon, Cambs. PE29 6FN, UK.
Tel: +44 1480 411600 Fax: +44 1480 412266
Website: www.displaytouch.co.uk

Easy way to make PCBs

At SILICON CHIP, we're often asked how to make printed circuit boards at home with a minimum of chemicals – and fuss!

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You get 5 sheets of 215 x 280mm transfer film in each pack, which retails for $35.00.

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Jaycar Electronics
(All stores and resellers Australia-wide)
Tel: 1800 022 888
Website: www.jaycar.com.au

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4D Systems specialises in using OLED and LCD technology with embedded custom graphics processors, suiting the needs of anyone, from hobbyists to large scale companies, requiring an embedded solution.

Ever wanted a display platform which you can develop with easily, maybe interface with Arduino, Raspberry Pi or the Intel Galileo?

4D produces a range of development kits which include either a 3.2" or 4.3" display module mounted on an aluminium stand with a display bezel, and feature breadboards on the back for prototyping circuits.

If you want to develop with a host, 4D is also releasing versions with an Arduino or Raspberry Pi B+ mounted next to the breadboard. More variants will also become available over time.

They have just released two primary displays for the A, B and B+ Raspberry Pi. The 4DPi-32 has a 3.2" 320x240 display and the 4DPi-35 has a 3.5" 480x320 display.

Contact:
4D Systems Pty Ltd
Unit 7, 103 Sargents Rd, Minchinbury NSW 2770
Tel: (02) 9625 9714 **Fax:** (02) 8834 0747
Website: www.4dsystems.com.au

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Tel: 1300 360 251
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Vintage Radio

By Lindsay George

The evolution of those magnificent Kriesler Multisonic stereograms

Built into handsome timber cabinets, Kriesler's top-of-the-range 11-95, 11-102 & 11-103 valve stereograms were beautifully made, featured carefully-designed audio stages with multiple speakers and even included electrostatic tweeters.

The Kriesler model 11-102 stereogram boasted six speakers, bass, treble & balance controls and pushbutton selector switches. The 11-103 is similar but had glass dividers around the turntable and brushed aluminium inner walls.

THE ARTICLE by Rodney Champness on the HMV R53A radiogram in July 2014 brought back memories for me of the time when, as a 16-year-old lad in country NSW, I first sighted the Kriesler model 11-77 stereogram. It was at the Kriesler agent's store in Cowra (230kms west of Sydney) and the year was 1959!

To put all this in context, stereo sound had just been introduced in Australia. I haunted Suttons Radio after school each day and eventually persuaded the owner's son to allow me to give the first public demonstration of stereophonic sound in the Presbyterian church hall. The reaction to a steam train virtually crossing the stage during one of the first demonstration recordings is still vivid in my memory.

Now Suttons had the AWA agency and our demonstration unit was a mono radio/record player cabinet (with a stereo cartridge), with an added amplifier and speaker to create stereo. By contrast, the Kriesler 11-77 was a quantum leap in one-piece design, with beautiful walnut cabinetry and an endearing high-frequency response. It still clung onto a round dial and featured separate volume and tone controls, with the knobs flashed with gold trim. It was fitted with a plate aerial and a Garrard GCS 10 turntable and understandably, I was rather envious.

Four years later, I had moved to

Sydney, paid off my first block of land, married and built a house. We moved in with sheets for curtains, no carpet and my first Kriesler Multisonic, a model 11-95. This again was a departure from the norm by the Kriesler designers and featured top-mounted controls with stylish gold embellishments, a Garrard Lab AT6 turntable with a detachable headshell and a complement of six speakers – two 12-inch woofers, two midranges and two Magnavox E3.5 electrostatic speakers.

Incidentally, a word of warning here. **The electrostatic speakers have HT applied to them via a 1MΩ resistor and this polarising voltage can give you a very nasty shock.** The electrostatics themselves are driven from the plates of 6BQ5 valve output stages via two series capacitors.

In the 11-95, a switch allows the signals to the electrostatics to be shorted to ground, so that they can effectively be disabled for scratchy records or if there is a lot of high-frequency noise. This switch also further reduces the treble fed to the midrange and woofer speakers (which are connected in parallel) due to the extra loading.

Magnavox stated that the electrostatics were capable of producing sound from 5kHz to well above the audible hearing range. In practice, they certainly enhanced all stringed, reed and percussive instruments. It's worth noting that the March and October 1964 issues of *Radio, TV & Hobbies* featured Playmaster designs that also used these quite revolutionary tweeters.

The set didn't have separate tone controls for each channel but it did sport inputs for a dynamic microphone (supplied). This allowed users to sing along or announce on one channel (I don't think the word "karaoke" had been invented at that time). There were also headphone and extension speaker outlets and the set included provision for recording and playback.

A highlight of the Kriesler 11-95 was its handsome honey-coloured, strip-maple, piano-finished cabinet, manufactured by Blandford and West Pty Ltd. It was available in teak, walnut or rosewood as well and it boasted an illuminated turntable bay and a friction-controlled self-lowering lid. Its circuitry had been changed from the single-ended 6M5 valve output stages in the 11-77 series (ie, one valve in each channel) to 6BQ5 output stages. And although it still used a standard

A BSR UA15 record changer was standard on the 11-102 but this can easily be upgraded to a Garrard AT6 as shown here. Note the microphone clipped to the underside of the hinged lid.

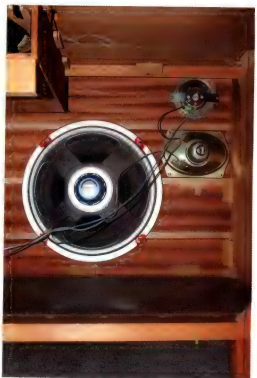
superheterodyne AM radio circuit, this now had a ferrite core antenna for added selectivity and sensitivity while still catering for an external aerial in country areas.

Best of all, this stereo valve set was powerful and it was capable of producing true hifi (for the time) through its Australian-made Magnavox speakers which were mounted on a substantial baffle board. In fact, some care was needed to prevent acoustic feedback from intruding into the turntable via the Sonotone 9TA ceramic cartridge, particularly at high volume levels when there was lots of bass in the recording.

Following on from the successful 11-95, the design was completely revamped for the 11-102 and 11-103 series. The chassis now departed from the usual "L" type and instead was now a long, narrow design which accommodated full treble and bass controls and a substantial push-pull output stage using the renowned 6GW8 triode/pentode valves. An EM84 "magic-eye" tuning indicator was also incorporated into the 102, while a stereo balance/tuning meter indicator was used in the 103 model.

Both sets retained the pushbutton selector switches, while the savings in chassis space allowed a tape player and records to be stored in two top compartments.

In addition, the 11-102 and 11-103 designs both had a separate power



The 11-102 included two 12-inch woofers, two midrange drivers and two Magnavox E3.5 electrostatic speakers. The 11-103 used an extra pair of midrange speakers, bringing the total speaker count to eight.

supply which was mounted away from the main chassis in the lower part of the cabinet. This not only left valuable chassis space for the RF and audio circuitry but also contributed to reducing the hum level. In fact, the Kriesler designers paid great attention to keeping hum levels low. For

Fig.1: the circuit details of the Kriesler model 11-102 (the 11-103 is almost identical). It uses eight valves – two in the AM tuner section (V1 & V2), five in the stereo audio amplifier stages (V3-V7) and one for the rectifier (V8). It also uses a magic eye tuning indicator whereas the 11-103 using a tuning meter/balance meter.

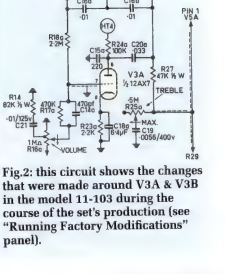


Fig.2: this circuit shows the changes that were made around V3A & V3B in the model 11-103 during the course of the set's production (see "Running Factory Modifications" panel).

example, an adjustable hum-bucking resistor was fitted across the filament winding, while an earthed shield was fitted to the turntable to prevent induced motor hum. Another shield was used adjacent to the power supply.

The 11-102 was apparently a "poor man's" version of the 11-103. It basically retained the identical circuit but did away with many of the embellishments of the 11-103. A cheaper BSR UA15 changer was also fitted but this can be easily upgraded to a Garrard AT6.

The Mastersonic version, which is the model 11-103, has two additional midrange 64SIC speakers, bringing the total speaker count to eight. This deluxe model also boasted fancy plate glass dividers around the turntable, while the inner side walls of the top compartments were finished in brushed aluminium. Its considerable dimensions were 119 x 77 x 44cm (W x H x D), which meant that its top was at a comfortable height for the user.

11-102/103 circuit details

Fig.1 shows the circuit details of the Kriesler model 11-102 which is almost identical to the 11-103. It uses eight valves in all – two in the AM tuner section (V1 & V2), five in the stereo audio amplifier stages (V3-V7) and one for the rectifier (V8). As previously stated, a magic eye tuning indicator was used in the 11-102, whereas the 11-103 used a tuning meter/balance meter.

As shown, the AM radio section uses a 6AN7 (V1) as a self-oscillating mixer. This feeds a 455kHz IF stage, with a 6N8 (V2) serving as an IF amplifier/rectifier/AGC stage. Its output

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is then fed to a pushbutton switch assembly (labelled "Bank 1") which selects between the AM radio and the turntable (record changer) and feeds the selected signal to the audio amplifier stages via stereo volume control potentiometer R16a & R16b.

The output from each volume control wiper is fed to one half of a 12AX7 dual triode valve (V3a & V3b) which serves as an audio preamplifier. These preamp stages then drive two ½6GW8 triode stages which operate as phase splitters and in turn drive two ½6GW8 output pentode stages operating in push-pull mode. Their outputs drive the woofer and midrange loudspeakers via speaker transformers T2A and T2B, while the electrostatic speakers are driven from the plates of the output valves via .01µF capacitors (C22a & C22b).

On this set, the signal and HT drive to the electrostatic speakers can be open-circuited using Bank 2 of the pushbutton switch assembly (eg, to reduce high-frequency noise). This arrangement differs from that used in the 11-95, whereby the signal drive was shorted to ground.

11-95 amplifier circuit

By way of comparison, Fig.3 shows the audio amplifier details for the 11-95 (the AM tuner and power supply stages are virtually identical to those used in the 11-103). As can be seen, the selected audio signal is fed to one half of a 12AX7 twin-triode preamplifier in each channel (V3A & V3B) and this then drives a second ½12AX7 triode (V4A/V4b) via stereo volume control R19A/R19B. V4A & V4B in turn drive 6BQ5 single-ended output stages (V5 & V6).

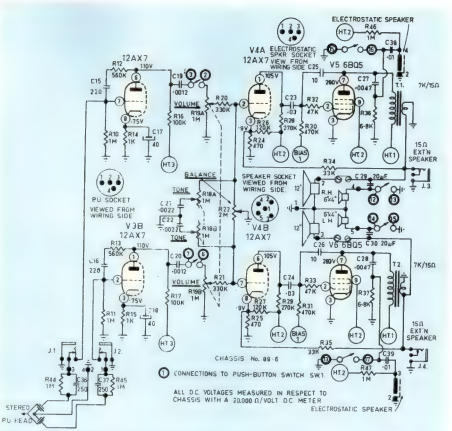

Fig.3: the audio amplifier details for the 11-95. The selected audio signal is fed to one half of a 12AX7 twin-triode preamplifier in each channel (V3A & V3B) and this then drives a second ½12AX7 triode (V4A/V4b) via stereo volume control R19A/R19B. V4A & V4B in turn drive 6BQ5 single-ended output stages (V5 & V6).

Servicing the changers

The changers in these units are now 50 years old which means they need to be serviced before being used again. This involves removing the changer from the cabinet, dismantling it and cleaning away all the old, congealed grease from the automatic mechanism hub and slides. These parts are then lubricated sparingly with LMM light graphite-impregnated grease.

All pivots, including the arm mechanism pivot, should be lubricated with light machine oil (use baby oil, which is far more refined and cheaper than ordinary oil). Garrard recommended using oil only for the platter bearings and spindle (not grease) plus an occasional drop on the lower motor bearing.

Next, the idler wheel needs to be cleaned. If the rubber is still pliable but shiny (and not a sticky, unsalvageable mess), clean it using a little lacquer thinner, then scuff the drive surface with 400 wet-and-dry paper. This scuffing should be done using a circular motion around the wheel, so that you don't get flat spots!

The idler spindle should then be cleaned and lightly oiled, after which the idler wheel can be reinstalled. Once it's in place, check that it rotates easily, then check the spring tension. Retension the spring if necessary to ensure the idler wheel makes firm contact with the rim of the platter. It may also be necessary to clean the inner rim of the platter to ensure smooth operation.

If the idler wheel is beyond repair, it shouldn't be too difficult to source a replacement via the net.

The next step is to check the cartridge. If it's a Sonotone 9TA, chances are that the silver-plated contacts on the rear plug that goes into the cartridge body are tarnished. If so, these should be cleaned with silver dip and allowed to dry before re-installation. Check that the cartridge weight after reassembly is at six grams on the LP disc.

The muting switch in series with the fine leads from the changer arm should also be checked and cleaned with contact cleaner. After all these years, secondhand 9TA NOS ceramic cartridges are often not worth buying. That's because the glue used to attach the needle bridge to the ceramic bars lets go unless the unit has been sealed from the elements or housed in a dry environment. One option is to replace the ceramic cartridge with a similar new one from WES Components in Ashfield NSW (Part No. PC06 – see www.wagneronline.com.au/pc06/9/ps/).

Circuit repairs

A few circuit repairs and modifications are also necessary to ensure

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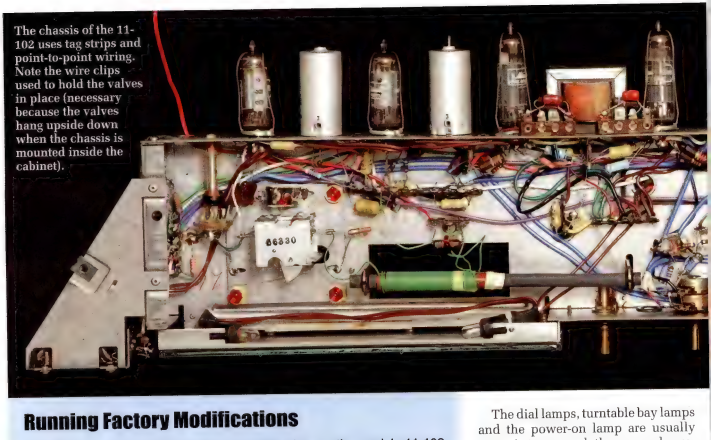


The chassis of the 11-102 uses tag strips and point-to-point wiring. Note the wire clips used to hold the valves in place (necessary because the valves hang upside down when the chassis is mounted inside the cabinet).

Running Factory Modifications

Kriesler made several running factory modifications to the models 11-102 and 11-103 during the course of their production. These were as follows:

Model 11-102

(1) Change C25a, C25b, C25c & C25D to 2000V polyester capacitors (up from 400V).

(2) Fit a 22Ω 0.5W resistor in the cathode output lead from the 6CA4 rectifier to protect the power transformer in the event of a short circuit.

(3) Change C19a, C19b from .01μF to .033μF.

(4) Change R15c and R15b from 1.2MΩ to 1.5MΩ to improve frequency response.

Model 11-103 Master Multisonic

(1) Some dial lamps were found to be noisy (I had never encountered this before), affecting both gramophone and radio reproduction.

(2) Volume control changed to 1MΩ tapped pot with an 82kΩ resistor and series 0.01μF/400V polyester capacitor fitted between the tap and ground (essentially a loudness a facility).

(3) R27 (47kΩ) added between pin 1 of V5A and the junction of C20, C16 & R19.

(4) C19 and connection to C20 deleted.

(5) A .0056μF/400V polyester capacitor wired in series between the moving contact of R25 and ground.

(6) R25 reconnected to junction of the added R27 above and pin 1 of V5A (applies to both channels) – see circuit diagram (Fig.2).

(7) A Sonotone type 21T cartridge was substituted because of its more robust construction, higher compliance and drop-proof design.

reliability and to improve the sound production from these superb, now sought-after designs. First, all electrolytic and wax paper capacitors should be replaced. Strangely, the mustard-coloured Mullard/Philips capacitors seem to hold up and these will generally be OK.

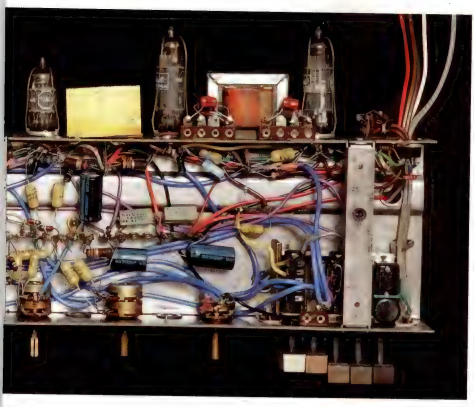
The dial lamps, turntable bay lamps and the power-on lamp are usually 300mA types and these can be replaced with 150mA types. This will reduce the current consumption and reduce the initial switch-on surge current from the transformer. If no valves light up, suspect a burnt out fuse-wire. This fuse-wire is inconspicuously soldered across a tag strip in line with the filament supply on the separate power supply chassis. The initial filament current can briefly peak at 8A or more before settling back, so standard light fuse-wire just won't hack it!

After 50 years, it also pays to remove and check the speakers for dust build up and for silverfish, moth or rodent damage. Repair and refit them if possible. Alternatively, Etone Australia has a good repair service or they can supply good-quality replacement loudspeakers.

If hum is abnormally intrusive, try adjusting the hum bucking resistor (R13) for minimum hum.

Owned by Philips

Philips purchased Kriesler in the 1950s and apparently allowed their engineers free reign to create such marvels as the 11-102 and 11-103 stereograms for us to enjoy. As far as I know, the Mastersonic was the last of the valve designs although Kriesler did go on to produce a three-piece transis-



torised Multisonic stereogram design.

This sold-state unit was designated the model 11-118 and it utilised large fully-sealed speaker cabinets aptly called "Custom 15". That name was used because they housed the magnificent curvilinear 15-inch cast Magnavox speaker with a 3-inch tweeter in a 2-way system.

I modified the ones I have with additional damping material and by fitting a quarter section (ie, 6dB/octave) crossover network. To this day, they are driven by my prized SILICON CHIP amplifier and an EA control unit from December 1996. I must admit to now lusting after the superior Majestic loudspeaker recently described in SILICON CHIP.

Perhaps the Majestics should be my next "ultimate upgrade" for my 11-102 Multisonic?

Original service bulletin

Finally, if any reader would like a copy of the parts lists or a copy of the original maufacturer's service bulletins for the above models, I would be happy to email these (lgeorge3@bigpond.com). The Historical Radio Society of Australia (HRSA) is another great source of information. They have a great selection of circuit diagrams for valve related gear and a valve bank! Email ron.soutter@dimensiondata.com for membership details.

Another source of reasonably-priced valves is Joe Oust – see oost@pacific.net.au

Footnote: thanks to Peter Calleja of the Historical Radio Society of Australia for supplying the factory-approved modifications and to Kevin Poulter for his photographic expertise. SC

The controls, input/output sockets and the tuning dial are all mounted on the top of the cabinet to make them easy to see and reach. Two dial pointers are used, so that the stations for all states could be spread out on a long narrow dial (rather than a large rectangular one) while keeping the pointer travel reasonable.

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Better antenna for entertainment unit

I have built a mini entertainment unit similar to your February 2014 issue project. The radio I purchased is a mid-range JVC/Kenwood. I have experimented with simple aerials as described in your text. Although FM reception is reasonable, the AM reception is dismal to say the least.

Compared to the old AM-only car radios of the past, it would appear AM reception has declined significantly. My location is a fringe reception area but some of my cheap clock radios perform better on AM. I have read that because most modern cars have small aerials or aerials built into the windscreens, the trade off is an in-line amplifier.

Would an old-style car radio aerial work mounted on the roof of my house? What is the best solution as far as an alternative FM/AM aerial? A. D., via email).

● The radio would undoubtedly perform better if it was connected to a car radio whip antenna, particularly if it was on the roof of your house and with an effective ground plane connected to the shield connection. A metal roof would be very good and would also provide shielding against light dimmers and other EMI sources in the house.

5V switchmode power amplifier

I am very interested in building a class-D amplifier and I like your Mini-D project (SILICON CHIP, September 2014). My issue is with the power supply. I would prefer a 5V amplifier, as I can easily get batteries and chargers (5V USB supplies and chargers are readily available cheaply on the web).

I notice Texas Instruments also have a version of the chip you have used, the TPA3130, that will run from a 5V supply. Would you consider a version using the TPA3130? (A. P., via email).

● While the TPA3130 has a wider operating voltage range than the TPA3113 and can deliver more power, it also requires a more complex circuit with proper output filtering, costs more and is harder to obtain. None of these rule it out as a possible future project but it would be intermediate in cost and complexity between the Mini-D and the CLASSiC-D.

We certainly could design a project around that chip but in the meantime, we have published a simple single-chip Class-B amplifier project in the November 2014 issue. It's only 5W per channel but will run off 5V and depending on what you want to do, might suit your needs.

Sun tracker design with a microcontroller

I am interested in building a device to track the Sun. I am not thinking in commercial terms. I am just looking for a new challenge in an area I haven't worked in for many years. I think the combination of mechanical, electrical and programming challenges will entertain me for some time.

I have a background in engineering (university and early career) and computers (coal face for 40-odd years) and am an inveterate "DIY-er" over a

Shunt Regulators Are Inefficient

I recently purchased a 5W (22V) solar panel to trickle charge the 12V battery in my car. It provides about 300mA in full sun. The car has a constant 30mA drain, hence the need for a trickle charge.

However, left on all the time I believe it may overcharge the battery. So I decided that a shunt regulator section, as described in the February 2008 issue of SILICON CHIP would be appropriate to regulate the voltage.

I built the shunt regulator section and it works OK, limiting the voltage to about 14.4V (I used a 13V zener). However, when I measure the current going into the battery from the regulator when it is charging and below cut-off at around 13V, it is only 110mA. The full 300mA is going into the shunt regulator but only 110mA is coming out. If the measurement is correct, I am losing two-thirds of the current from the panel while the transistor is turned off.

I used a BDX54C Darlington transistor instead of the specified TIP117 as it was easier to obtain and I wonder whether this is a factor. The article says nothing should happen until the battery is charged so I am puzzled as to what is wrong. Do you have any idea what could be happening? (B. D., via email).

● In essence, shunt regulators are pretty crude and the basic zener diode circuit explains why it may operate at lower voltages than desired. But if you're stuck with the shunt regulator, try putting a resistor of say, 220Ω, between the Darlington's base and emitter.

The problem is that the zener breakdown voltage drops at very low currents and so the transistor turns on at a lower voltage than it should. Increasing the zener current should reduce this problem. You may find a different resistor value is better but it's hard to say without experimenting.

A series regulator will always be more efficient than a shunt regulator. Have a look at the linear pre-regulator circuit from our Low-Power Car/Bike USB Charger in the May 2010 issue.

It draws very little current from the load (microamps) and has little effect unless the incoming voltage rises above the limit threshold, which can also be adjusted by changing the zener diode.

variety of trades. The bit I don't feel confident about is the choice of computer chip. It seems there is a big range of features and capabilities available from Micromite (and its bigger brothers) through to Arduino and Raspberry Pi. I don't want to go down one of the possible paths and find it doesn't have enough features or at the other extreme, it is an over-kill solution.

I need to be able to accept electrical input from signals to drive the tracking process, do the maths and then output electrical instructions to what I guess will be stepper motors. It would be good to be able to connect to the device either by making it a peripheral to a PC (USB?) or by connecting to a network. I hope your broad experience will help me to make this choice. (B. D., via email).

● Unless you want such niceties as data logging, you don't need the complexities of a microcontroller. A circuit such as that in Circuit Notebook, May 2009, would be suitable.

However, if you do want to use a microcontroller, the minimum that's worth using these days is the PIC32MX series. While we don't know exactly what you are trying to do, a PIC32MX will probably be more than powerful enough for the job.

You could start with the 44-pin Micromite which has a USB interface (albeit via a serial converter chip). If you find programming it in BASIC too limiting, you can get a PICkit3 and program it in C instead.

The advantage of something like the Raspberry Pi is that you get a complete operating system with lots of extra services to save development time. But it's also slower to start up, more expensive, harder to interface to and so on. If you like the idea of having an OS (operating system) rather than just programming on the "bare metal", take a look at the Beaglebone Black.

However, we really don't think you need all that complexity for a solar tracker. Add motor drivers and some simple light monitoring circuity to a Micromite and it will do the job just fine.

High-voltage generator search

I'm thinking about building a high-voltage generator to generate about 3-30kV. I was considering using a Cockroft-Walton voltage multiplier, as mentioned on page 93 of the March 1994 issue. I've seen some of your articles that use this type of circuit but couldn't locate them with the word search function in your website; it's not the Jacob's Ladder circuit.

Do you know which other issue or issues contain this type of circuit? (P. C., via email).

● The most recent reference appears to be in Circuit Notebook, July 2011: "Geiger Counter uses Cockroft-Walton Multiplier". However that one "only" generates 500V. You can increase the number of stages in the multiplier but you will encounter diminishing returns pretty quickly.

You can search on the SILICON CHIP website for this by putting "voltage multiplier" in the word search, including the quotes. That search only goes back to January 2004. You can also check our project index (**siliconchip.com.au/Articles/ProjectIndex**) but the only reference you are likely to find is for March 1994.

However, 3kV is a typical polarising voltage used for electrostatic speakers and we published DIY electrostatic speakers in the February-April 1995 issues. The April 1995 issue has the circuit and it does indeed generate 3kV from a 5V input. It uses a Cockroft-Walton multiplier, driven from a flyback converter. We doubt that the (small) transformer used is still available but

Correct Charging Of An Auxiliary Battery

First, thank for a great monthly magazine, I look back through my 180 copies on a regular basis and find it amazing how many topics and construction articles you cover.

I have a Toyota Prado Diesel 2008 with dual battery setup. My caravan always gets its power from the auxiliary battery and I have a Baintech voltage switched relay (VSR).

I have always thought it worked OK and have never had charging problems that I knew of. Then, with the caravan connected, I returned home via a stop of about two hours in a town leaving the fridge running, which would have taken the auxiliary battery down a bit. I looked at my voltmeter in the dash (from main battery) and it was down to 12.9V.

Checking my auxiliary battery showed that it was down to 10V. It had obviously not been charging as the Baintech VSR requires 13.4V to cut in. I turned the fridge off and slowly everything returned to normal, with 13.8V at the main and auxiliary batteries.

Trawling the internet showed that there are many stories of similar problems and fixes from a simple diode in the sense wire to up the voltage the alternator puts out by 0.5V to dedicated DC/DC isolator chargers. I tried the diode solution and it does increase the voltage by 0.5V but the ECU or whatever slowly winds this back at times and causes the same issue of not charging the auxiliary battery.

The question is, what kind of signal could the ECU (VCM) be sending to the alternator to control it? I did not want to try disconnecting it to see what happens in case it causes damage. Would it be safe to measure it with a voltmeter? It would appear it is a common problem in many newer vehicles. When the engine is hot, they only charge to around 13.2-13.4V. (G. H., via email).

● The vehicle's ECU controls the alternator by changing the field excitation but we could not tell you the nature of its control signal. We would not recommend disconnecting it.

The alternator's output voltage is typically set at 14.4V (or very close to it) if the vehicle has just been started (to top up the battery), or the headlights and/or air-conditioning are on.

You can confirm this when driving your vehicle by checking your dashboard voltmeter. If you do find that the voltage is at 14.4V when headlights are on, it would make sense to always drive with headlights on, when towing the caravan with the fridge turned on. You may find that turning the headlights on only increases the battery charge voltage when idling.

Note that modern vehicles reduce the charge voltage when battery temperature is high. Since the house battery will be cooler (not being in the engine bay), it may not always charge properly. The only sure solution is to use a "caravan booster".

Feedback On The 12-Digit Frequency Counter

The SILICON CHIP design for the 2.5GHz 12-Digit Frequency Counter was published in the British magazine "Everyday Practical Electronics", in January & February 2014. Recently I have finished constructing this project and have been successful in getting it working. I had some difficulty sourcing the blue display modules so I found some alternative red ones on eBay which appear to work OK.

I have also integrated the GPS timebase module into the lid. I could not source either of the GPS receiver parts published in the magazine, so I grafted in a different surface-mount part (SiRFStarIV A2235-H). It works very well, although it can take up to 13 minutes to start issuing the 1PPS signal! Once the signal is present, it appears very solid and stable.

I have not tested the high frequency Channel B, as I don't have a frequency source high enough. My signal generator is limited to 21MHz. I tried putting this into channel B but it didn't respond. Perhaps this is too low a frequency? I think I will try to build a high frequency test circuit for this channel to see if I can get something out of it. So far I am very pleased with what promises to be a very accurate instrument. Many thanks. (B. C., Hertfordshire, UK).

- Many thanks for your positive feedback regarding the 12-Digit Frequency Counter project and for the photos showing the very nice job you made of it.

If your GPS receiver module takes about 13 minutes to begin issuing a 1pps signal, try moving it over near a window. It sounds as if it's one of those modules with a flat ceramic antenna on the top and we've found over here that most of these work a lot better if they are near a window so they can pick up more of the GPS satellite signals.

you could probably wind your own.

Another option may be to scrounge the EHT circuit (typically a flyback regulator) from a defunct CRT monitor or TV. Regardless of how you do it, we urge caution, since these sorts of voltages are dangerous and not for the uninitiated!

Phantom power for a Behringer microphone

I have just bought the PCB for the 48V Dual Phantom Power project in the November 2014 issue of SILICON CHIP magazine and look forward to building it but I have question regarding its use.

I recently built the USB recording interface from the June 2011 edition and would like to use the two units, together with a Behringer C-1 condenser microphone I already have. The mic has a nominal impedance of 100Ω with a load impedance of 1kΩ and an open-circuit sensitivity of -33 ± 2dBV (0dBV = 1V/Pa). It requires 36-52V at 2.5mA but the article states the current output is 6.5-7.7mA.

Would the phantom power supply be suitable to use with the recording interface to record voice to my PC or would I need to change the 6.8kΩ resistors to get the 2.5mA the mic needs? (P. V., Innisfail, Qld).

- The 6.5-7.7mA current for the Phantom supply refers to the short-circuit current. With a 2.5mA load from the Behringer microphone, that would produce an 8.5V drop across each 6.8kΩ ohm resistor (with 1.25mA supplied by each resistor) and so the Phantom supply would provide 48V - 8.5V = 39.5V. So the supply will deliver the correct current and voltage that is within the 36-52V requirement for that microphone.

This is not surprising as the Behringer microphone would have been designed to operate from a standard 48V phantom supply that has 6.8kΩ supply resistors.

Query about flux paste

I am going to construct the Digital Effects Unit in the October 2014 issue. The article refers to applying flux paste after soldering the SMD device prior to using solder wick. I am confused as to which paste I need as Jaycar Electronics have two types: Cat. NS3039 & Cat. NS3046. Can you please clarify which one I need? (G. C., via email).

- NS3046 is solder paste, so it's flux with embedded solder balls. It's used for hot air or infrared reflow soldering. We wouldn't recommend you use it with a hand-held soldering iron as you will end up with solder splattered all over the place.

NS3039 is what you want; it's just flux and can be used in a wide variety of situations including soldering new parts and rework. Spread a thin film on the pads before soldering to enhance solder flow and add it to joints to reflow them and to assist solder wick to carry away excess solder. We believe that the AIM products are made in Australia by Chemtools and are top quality.

12V-to-5V USB supply causes RF interference

Have you any articles on building a 12V-to-5V USB Linear Power Supply with at least two USB sockets? I picked up a regulator kit at Jaycar and will fit a larger heatsink. My dash-cam draws 0.39A and I expect the GPS will also draw a fairly marginal current.

I need it to run my GPS and dash-cam as the switchmode PSUs cause radio interference. (A. G., via email).

- We think you will find that your GPS draws 1A or more at 5V and that your dash-cam also draws more than 0.39A at 5V. Even supposing that your figure is correct, a 12V-to-5V linear supply to provide around 1.5A is going to have quite a substantial power dissipation. This could be 14W or more when the battery is being charged. That means you will need a substantial heatsink.

If a 12V-to-5V switchmode supply causes significant radio interference, it suggests that you are in a weak signal area or your car radio installation could be improved. It may also be possible to reduce the radiated interference from the switchmode supply by using one of those clip-on ferrite suppression sleeves.

32V audio amplifier for school project

I was wondering if the Ultra-LD Mk.3 200W amplifier module's power supply and quiescent current adjustment (September 2011) could run off 32V power. That's because I would like to make the Ultra-LD Mk.3 135W/Channel Stereo Amplifier (March 2012-April 2012) for a school project or is there a similar stereo amplifier or

power supply that runs from 32V? (N. W., via email).

● We assume you mean that you want to run it from 32V DC. That would require a number of biasing changes but the power output from such a low supply voltage would make it a waste of time. The maximum power output you could expect would be of the order of 10 watts into an 8-ohm load.

The power output is limited by the maximum undistorted peak-to-peak output voltage that the amplifier can deliver to the load. With a supply of 32V DC, that is about 25V p-p (at most). Other amplifier circuits will have the same limitation.

Being limited to 32V really does narrow the options as far as audio power amplifiers are concerned. However, you might like to consider building the Tiny Tim amplifier (SILICON CHIP, October & December 2013 and January 2014). Instead of powering from the specified 2 x 15V transformer you could run it from a 2 x 11.5VAC @ 1.25A power supply available from Jaycar (Cat. N16680). This would obviate the need for any 230VAC mains wiring.

The resultant power output would be very close to the performance figures we quote and the amplifier would be a good combination with the Tiny Tim Loudspeaker from the October 2013 issue.

Mains timer capacitance query

In the August 2012 issue of SILICON CHIP, in your "Mains Timer for Lights and Fans" project, you state that "The 3.3MΩ resistor minimises frequency variation with supply voltage by isolating the input capacitance of pin 11". I think this means that the input capacitance of pin 11 would impact the capacitance of the RC oscillator formed by the chip and the external components. However, the Philips data sheet says: "The function of [the resistor] is to minimise the influence of the forward voltage across the input protection diodes on the frequency". This is different and not as intuitive. Do you understand it?

It's a neat project and kudos for getting away from a microcontroller-based solution. I thought the parallel full-wave rectifier power supply was particularly clever. (G. B., via email).

● The only way we can see the forward voltage of the input protection diodes having any effect would be if the input protection was actually activated, which could only happen if there is a great deal of ripple on the V_{DD} pin and if the timing capacitor is charged up to the full supply voltage (or nearly so).

In that case, if V_{DD} dropped, it would be possible for the timing capacitor to discharge through the protection diodes and having a series resistor would limit the speed of discharge. So perhaps that it what it is there for.

In this case, the 100nF value is so much larger than the change in capacitance of the protection diodes that isolating it wouldn't make much difference. With a much smaller timing capacitor, it might though.

Unfortunately, the "cleverness" of this circuit turned out to be a drawback as it turns out you can't connect a load directly across the switch and hook this unit up at the same time. The

PIC Programming Problem

I have been trying to program the PIC32MX150F128B chips for the Micromite (SILICON CHIP, May & June 2014) and MPLAB X keeps giving the error message "Failed to get device ID". I am running v1.41 on Windows 7 (have also tried it on XP with the same result). I have also tried v2.10 and get a similar error message.

Do you have any idea what I am doing wrong? (R. S., Huntly, Vic).

● It sounds like a communication problem between the PICkit3 and the PIC32 chip or the PIC32 chip is not operating correctly. There could be a number of causes for this, including:

(1) Transposed or wrongly connected PGED and PGEC lines.

(2) PGED/PGEC wires are too long (although this usually causes failure later on in the process).

(3) Wrongly connected MCLR line.

(4) Insufficient bypassing on V_{CC}/GND or some V_{CC}/GND pins not connected to correct power rails.

(5) Missing V_{CAP} capacitor or too little capacitance or too high ESR

We don't think it's a software problem; it's likely to be an issue with your programming rig.

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Query About Fly-back Operation Mosfet Circuit

My question is how does the "fall back" time in a Mosfet affect the secondary voltage in a fly-back transformer? (P. L., Ventura, California, USA).

● We haven't heard the term "fall back" time with regard to Mosfets. It you are referring to the reverse recovery diode (intrinsic to the Mosfet semiconductor construction) that is generally slow compared to a fast diode, then this will have an effect on circuit response. Some Mosfets have a fast recovery diode action instead.

What effect the intrinsic diode has is dependent on the circuit. For a single Mosfet fly-back circuit, the reverse diode does not conduct as the drain does not go negative with respect to the source (for an N-channel Mosfet) and so a separate fast diode is placed between the drain and supply to clamp the voltage going above the supply.

Alternatively, a zener diode can be used as a clamp by choosing one with a voltage rating such that it conducts before the Mosfet's drain-source junction breaks down. It can be connected between drain and source, or between drain and supply via a series fast diode (cathode to cathode series connection) or placed in the gate drive to have the Mosfet conduct with over-voltage.

If the "fall back" time refers to the Mosfet switch-off time, then this won't affect the secondary voltage as the transformer would tend to be slower to respond at switch-off than the Mosfet. That's assuming that the Mosfet is chosen for its fast switch-off rate and that the gate is driven low at a sufficient rate for the fly-back transformer's operation not to be affected.

reason is that at the moment the switch is turned off, the directly switched load will continue to be supplied for half of the mains waveform through the rectifier diodes and ZD1 and this tends to blow up ZD1!

It works fine with just a load between the Aload terminal and Neutral though. It probably would have been better to have just used one rectifier and used half the relay to latch power on to the rectifier and the other half to switch the load.

Ultrasonic anti-fouling in the Caribbean

I recently assembled the Ultrasonic Anti-Fouling project (SILICON CHIP, September & November 2010) and all appeared to work but along the way I blew the fuse because I did not remove it before setting the 5V adjustment (my fault). I bought new fuses from a ships chandlers – they were GMA 3A (fast-blow, I believe).

With the new fuse it functioned as expected; some popping and clicking in our HF SSB radio and short sharp noises when I swam under the boat. Given the noise interference, I would want to turn the unit off each day when I use the radio for a short period. But now I have blown three of these GMA fuses each time at start-up.

Do I have the right fuses and if not what should I get? Slow blow perhaps? Is there likely any component damage that I should look for?

I am currently in Bonaire (southern Caribbean) on our 39-foot yacht and electronics stores are non-existent. I would love to get this device going since we are about to sail to Colombia where the barnacles are ferocious. I hope you can help. (A. P., via email).

● Yes, you could use a 3A slow blow fuse to prevent the fuse blowing. There is a high start up current due to charging of the supply capacitance that must be causing the fuse to blow.

Coax digital input for headphone amplifier

I'm a bit concerned as I assembled the headphone amplifier described in September & October 2011 some time ago but modern Blu-ray/DVD players only have HDMI or coaxial connectors. Is it possible to publish a coaxial adaptor for the input of the 2011 headphone amplifier?

My new Blu-ray/DVD player with a coaxial output has down-mix PCM which means it converts to LPCM in the digital audio output setting, so would it be possible via an adaptor to connect a coaxial cable to the amplifier's left/right input terminals? I'm hoping you can resolve this issue for me and perhaps many other SILICON CHIP readers (D. S., via email).

● The easy solution is to use a low-cost DAC such as the one we featured in the Tiny Tim Stereo Amplifier (SILICON CHIP, October & December 2013, January 2014). This is a standard item from Jaycar (Cat. AC-1631) and has coaxial and Toslink digital inputs. In the Tiny Tim amplifier, we powered it from a MiniReg PCB, as featured in the December 2011 issue.

Battery charger problems in motor-home

I have just returned from a 6-week trip in a new motor-home. I would like to point out to caravan and motor-home owners a couple of problems I have encountered which I suspect may be quite common.

I have a total of 400 amp-hours of "house" batteries. The motor-home was equipped with a 40A charger, labelled as "short circuit protected". It was not connected to the house batteries through a fuse as it should have been and consequently it burned out. Short circuit protection is NOT overload protection. It only shuts down when the output voltage drops to near zero which doesn't happen in battery-charging situations.

What is desperately needed is current limiting. I now believe that most if not all these chargers on the market suffer from the same problem. They have no internal current sensing to shut them down.

Similarly, the charging circuit from the motor-home engine alternator has no current limiting, just fuse protection. This also creates a problem, in that while driving, you assume the house batteries are being charged, whereas the fuse may have blown, leaving you with discharged batteries and no refrigerator power when you need it. Again, it requires current-limiting rather than just fuses.

All the standard system protection devices in caravans and motor-homes disconnect the battery loads when the battery voltage drops to a preset level. They don't control charging. This might be a good project for a SILICON CHIP project and should have a wide demand. (R. C., Parkdale, Vic).

● You would expect that a mains charger would have fuse protection

continued page 112

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Changing The Active Crossover's Quad Op Amp

Could you please tell me how much current your Active 3-Way Crossover board (SILICON CHIP, January 2003) requires to function optimally? I am thinking about casing it together with the amplifiers of my system. They already have a PSU, so maybe I could use it to power the crossovers as well, using different regulators. Can you see any potential issue in doing so?

Secondly, Texas instruments recommend the TLE2074 as an upgrade to the TL074 – see **www.ti.com/product/tle2074/description** or **www.ti.com/lit/ds/symlink/tle2074.pdf** They state that: "The TLE207x series of Jet-setting operational amplifiers more than double the bandwidth and triple the slew rate of the TL07x". However, I have read that a higher slew-rate is not always better for audio applications as it can create artefacts above the spectrum perceived by the human ear which nevertheless affect how we hear the processed sound.

Do you think that swapping the TL074 with the TLE2074 would improve the performance of the circuit? If yes, in which way? Or are there any other op amp options that you know that function better than the TL074s in this design? (J. S., via email).

● The power consumption of the total circuit is really quite low since the TL074 only draws about 1.4mA per op amp. Really, the specified 20VA transformer is far too big for the job but it might have been the only suitable one available at the time. So you probably can run the whole board from the supply in your amplifier.

There is little point in changing the TL074 op amps. Increased bandwidth can lead to a tendency to supersonic oscillation. There would be no improvement in circuit performance.

Ask SILICON CHIP

. . . continued from page 110

but on the primary side (230VAC) rather than on the secondary. Fuses would cause unwanted voltage drop while charging.

Most chargers would have an over-temperature thermostat cut-out that is essentially a current limit as the thermostat heats under current flow. A 40A charger with a big battery load like yours should not burn out. (One of our staff has a flybridge cruiser with six batteries and they would easily exceed 400Ah).

As far as the alternator is concerned, it too is essentially current-limited (by core saturation), so fuses are not appropriate. We think your charger could have been damaged by some other problem, such as high voltage in a caravan park.

Speed control has audible whine

I have just built and installed the 12V Motor Speed Controller kit from the June 1997 issue and am having trouble dealing with the noise it creates in the fan motor in my Holden Rodeo. I have only one of the diodes across the motor labelled D2, as only one came with the kit. I have looked at buying another MUR 1560 diode to see if it makes any difference.

Any ideas to reduce the motor noise, as turning the stereo up to mask it is not going to do my hearing any good? If this is common and cannot be fixed I will just have to buy an expensive resistor card; no problem but just a bit disappointing.

Would putting a bigger capacitor across the motor smooth out the waveform? The noise is heard throughout the whole of the speed range but is a little quieter at very low speeds. (J. E., via email).

● It is common for this controller to produce noise in a motor due to the switching on and off of power to control the speed. The frequency can be adjusted a little and that may reduce the noise when set to a frequency that does not resonate with the motor windings.

To alter the frequency, the 10kΩ resistor connected between pin 6 of IC1 and ground can be varied between 50kΩ and 4.7kΩ, using a 50kΩ trimpot with a 4.7kΩ resistor in series. Adjust the trimpot to get the minimum amount of noise.

Do not increase the value of C2 connected across the motor as this is there to reduce very high switching noise rather than filtering out the motor-driving pulsed waveform. If the capacitor is made too large, Mosfet Q3 and/or Q4 will be damaged.

Fitting a second diode (D2) across the motor is unnecessary. SC

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